

I. Introduction

The purpose of this cost-benefit analysis is to identify the establishments and industries potentially affected by the ergonomics rule (WAC 296-62-05101), and to evaluate the associated costs, benefits and economic impacts of the rule. The cost-benefit analysis also fulfills the rule-making requirements of the Administrative Procedures Act (RCW 34.05.328(1)(c)) and Executive Order 97-02.

A. Need for an Ergonomics Standard

Work-related musculoskeletal disorders (WMSDs) are a major contributor to workers' compensation claims, lost workdays and pain and suffering. Musculoskeletal (muscle, bone and connecting tissues) injuries and illness are often referred to as cumulative trauma disorders, repetitive motion disorders, or occupational overuse syndromes. Many employers and employees are unaware of either the risks, or the solutions for WMSDs.

Prior research shows that WMSD injuries occur throughout Washington industries. Risk factors for WMSDs are found in all types and sizes of Washington's workplaces. Many employers actively identify hazards and successfully reduce WMSDs, most often gaining information on ergonomics through trade associations and the Department of Labor and Industries (WISHA Division). However, almost two-thirds (62%) of employers have taken *no* steps to reduce WMSDs. Among those taking no steps, most believed they had no WMSD problems. Among those recognizing the problem, almost 40% had taken *no* steps (Foley and Silverstein, 1999).

The ergonomic rule focuses on risk factors for the largest category of WMSDs, called non-traumatic soft tissue disorders, excluding those injuries from slips, trips, falls, motor vehicle accidents or being struck by or caught in objects, (referred to as WMSDs in the remainder of this document). These disorders are often caused or aggravated by awkward postures; high hand force; highly repetitive motion; repeated impact; heavy, frequent or awkward lifting, and moderate to high vibration. They are often found in jobs characterized by repetitious work or manual materials handling.

The State of Washington Industrial Insurance Fund (hereafter referred as the State Fund) paid an average of \$285 million per year (1998 dollars) in WMSD claims between 1990 to 1998. In addition, the department estimates the average cost of WMSD claims among self-insured employers was \$138 million annually between 1990 and 1998. Total direct cost from WMSD generated insurance claims was estimated to average \$423 million per year during the period from 1990 to 1998. The total cost of WMSD injuries to the residents of Washington State is actually much higher than the above figure, as insurance payments from the State Fund and self-insurers do not fully compensate workers for lost time and income.

There is also evidence that workers make sizable out of pocket payments to treat WMSDs (Morse, et al, 1998) and that those employees afflicted with a serious WMSD experience

reductions in long term earning potential and family stability (Boden & Galizzi, 1999). Finally, there are sizable indirect employer costs associated with WMSDs. The indirect costs, that are the consequence of WMSDs, are borne by the employer in the form of higher absenteeism, turnover and replacement training costs as well as lower overall productivity.

Presently, the State of Washington has no specific regulations requiring active identification and control of WMSD risk factors. General regulations requiring an effective accident prevention program and the maintenance of a safe workplace apply to the prevention of WMSD hazards, but they have proven insufficient. An ergonomics rule would provide greater incentives for the identification and control of musculoskeletal hazards in the workplace.

B. The Proposed Ergonomics Rule

The purpose of the proposed ergonomics rule (WAC 296-62-05101) is to reduce employee exposure to workplace hazards that can cause or aggravate work-related musculoskeletal disorders (WMSDs). In workplaces where these hazards exist, employers must reduce them. Doing so will prevent WMSDs such as tendinitis, carpal tunnel syndrome and low back disorders. The rule is not designed to prevent injuries from slips, trips, falls, motor vehicle accidents or being struck by or caught in objects.

The proposed rule will apply only to employers with jobs having certain risk factors for WMSDs. In the proposed rule these jobs are designated “caution zone jobs.” The employer is expected to make a reasonable determination whether this rule applies. Only employers with “caution zone jobs” must comply with Part 2 of the rule. Employers with “caution zone jobs” must:

- provide ergonomics awareness education for workers in those jobs,
- analyze the “caution zone jobs” for WMSD hazards
- reduce exposure to identified hazards.

Employers may avoid the job analysis step by directly fixing their “caution zone jobs”. The rule does not include any requirements for the medical management of WMSDs or change any requirements for handling industrial insurance claims.

The proposed rule will apply to all types and sizes of industries in the State of Washington.

C. Flexible Provisions under the Standard

The department is aware that the rule will impose significant costs and present challenges to Washington businesses. The department has taken several steps to mitigate the impact of the rule, especially on small businesses. The following mitigation steps have been built into to the rule.

First, there will be a phase-in period, which includes delayed enforcement for small businesses. The department intends to undertake substantial efforts to provide assistance for small businesses in preparing for the rule during this phase-in period.

The rule is to be phased in over a six-year period, beginning with employers classified in selected Standard Industrial Classification codes (078 152, 174, 175, 176, 177, 242, 421, 451, 541, 805 and 836) and employing 50 or more annual full time equivalents (FTEs) in Washington State. The Department of Labor and Industries is covered under the rule in the first year. The first group will be expected to have awareness education completed and hazard analysis completed by July 1, 2002 and have hazard reduction completed by July 1, 2003. The remaining employers in those SIC codes and all other employers who employ 50 or more annual FTEs will be expected to have awareness education completed by July 1, 2003 and hazard reduction by July 1, 2004. By July 1, 2004, employers employing 11-49 annual full time equivalents (FTEs) in Washington State must comply with awareness education and hazard analysis requirements and hazard reduction must be completed by July 1, 2005. All other employers are expected to complete awareness education and hazard analysis by July 1, 2005, and hazard reduction by July 1, 2006.

Second, there is an option under the rule which allows an employer to follow specific criteria for identifying and reducing hazards, or to develop and use their own criteria which may be tailored to meet the employers' needs.

Finally, the department's method of assessing penalties for violations of rules allows a very substantial penalty reduction for small employers.

The scheduled phase-in has been accounted for in this cost-benefit analysis.

D. Legal Requirements

In accordance with the Revised Code of Washington (RCW 34.05.328) this cost-benefit analysis determines that the probable benefits of the rule are greater than its probable costs, taking into account both the qualitative and quantitative benefits and costs and the specific directives of the statute being implemented. The cost portion of the analysis is similar to the Small Business Economic Impact Statement (SBEIS) that was filed with the proposed rule.

Rulemaking Requirements

State agencies must satisfy specific legal and policy criteria before adopting or amending regulations. These criteria come from two sources: the Administrative Procedures Act

(RCW 34.05.328) and the Executive Order on Regulatory Improvement (No. 97-02). These sources set up complementary, but slightly different, review requirements.

Administrative Procedures Act

The Administrative Procedures Act deals solely with adopting or amending regulations. Before adopting a “significant legislative rule” the Administrative Procedures Act (RCW 34.05.328) requires L&I to:

- (a) Clearly state in detail the general goals and specific objectives of the statute that the rule implements;
- (b) Determine that the rule is needed to achieve the general goals and specific objectives stated under (a) of this subsection, and analyze alternatives to rule making and the consequences of not adopting the rule;
- (c) Determine that the probable benefits of the rule are greater than its probable costs, taking into account both the qualitative and quantitative benefits and costs and the specific directives of the statute being implemented;
- (d) Determine, after considering alternative versions of the rule and the analysis required under (b) and (c) of this subsection, that the rule being adopted is the least burdensome alternative for those required to comply with it that will achieve the general goals and specific objectives stated under (a) of this subsection;
- (e) Determine that the rule does not require those to whom it applies to take an action that violates requirements of another federal or state law;
- (f) Determine that the rule does not impose more stringent performance requirements on private entities than on public entities unless required to do so by federal or state law;
- (g) Determine if the rule differs from any federal regulation or statute applicable to the same activity or subject matter and, if so, determine that the difference is justified by the following:
 - (i) A state statute that explicitly allows the agency to differ from federal standards; or
 - (ii) Substantial evidence that the difference is necessary to achieve the general goals and specific objectives stated under (a) of this subsection; and
- (h) Coordinate the rule, to the maximum extent practicable, with other federal, state, and local laws applicable to the same activity or subject matter.

The Executive Order on Regulatory Improvement

The Executive Order on Regulatory Improvement (No. 97-02) established seven review criteria for state regulations that significantly affect “business, labor, consumers, and the environment.” The order directs state agencies to ensure that “[a]ny new rules or significant amendments for which a notice of intent to adopt is filed after the effective date of this executive order shall be consistent with its principles and objectives...”¹ The seven review criteria are:

1. Need. Is the rule necessary to comply with the statutes that authorize it? Is the rule obsolete, duplicative, or ambiguous to a degree that warrants repeal or revision? Have laws or other circumstances changed so that the rule should be amended or repealed? Is the rule necessary to protect or safeguard the health, welfare, or safety of Washington's citizens?

2. Effectiveness and Efficiency. Is the rule providing the results that it was originally designed to achieve in a reasonable manner? Are there regulatory alternatives or new technologies that could more effectively or efficiently achieve the same objectives?

3. Clarity. Is the rule written and organized in a clear and concise manner so that it can be readily understood by those to whom it applies?

4. Intent and Statutory Authority. Is the rule consistent with the legislative intent of the statutes that authorize it? Is the rule based upon sufficient statutory authority? Is there a need to develop a more specific legislative authorization in order to protect the health, safety, and welfare of Washington's citizens?

5. Coordination. Could additional consultation and coordination with other governmental jurisdictions and state agencies with similar regulatory authority eliminate or reduce duplication and inconsistency? Agencies should consult with and coordinate with other jurisdictions that have similar regulatory requirements when it is likely that coordination can reduce duplication and inconsistency.

6. Cost. Have qualitative and quantitative benefits of the rule been considered in relation to its cost?

7. Fairness. Does the rule result in equitable treatment of those required to comply with it? Should it be modified to eliminate or minimize any disproportionate impacts on the regulated community? Should it be strengthened to provide additional protection?

¹ In addition to the seven review criteria, the Executive Order requires state agencies to consult with major stakeholders while reviewing a regulation. Efforts to involve stakeholders in the development of this rule are discussed in the Concise Explanatory Statement accompanying the rule.

This analysis was completed to fulfill the requirements of section c of the Administrative Procedures Act and criteria 6 of Executive Order 97-02.

E. Organization of this Cost-Benefit Analysis

This cost-benefit analysis has been developed to support the Washington State Department of Labor and Industries ergonomics program standard. In addition to the introduction, it contains the following chapters:

- I. Introduction*
- II. Cost Estimation*
 - A. Cost methodology*
 - B. Compliance Cost by Element*
- III. Benefits Estimation*
 - A. Outline of Approach and Methods Used*
 - B. Direct Social Costs of WMSDs*
 - C. Unreported WMSD Injuries*
 - D. Indirect Employer Costs*
 - E. Anticipated Effectiveness of the Ergonomics Rule*
 - F. Qualitative Benefits not Included in Cost-Benefit Calculations*
 - G. Willingness-to -Pay Measures*
- IV. Conclusion*
 - A. Monetized Costs and Benefits of the Ergonomic Rule*
 - B. Comparison of ergonomic Rule Costs and Benefits*
 - C. Summary*

II. Estimating Compliance Costs for the Ergonomics Rule (RCW 34.05.328(1)(c))

A. Cost Methodology

The general procedure used to estimate the compliance costs for the ergonomic rule is similar to the methodology used in preparing the Small Business Economic Impact Statement (SBEIS) that was issued earlier in the rule development process. The cost procedure was as follows:

- determine which businesses must comply with the rule
- determine the number of employees and establishments with caution zone or hazard jobs as defined by the rule.
- estimate the time and personnel requirements to arrive at unit costs for meeting the different portions of the rule.

- estimate the unit control costs for reducing WMSD hazards.
- multiply the number of employees in caution and hazard jobs by the appropriate unit costs to arrive at total compliance cost.

This analysis utilizes information taken from the Washington State Employment Security Department (ESD), the Washington State Department of Revenue (DOR), the U.S. Occupational Safety and Health Administration (OSHA) and two surveys of Washington businesses conducted by the Department of Labor and Industries (L&I) and the Safety and Health Assessment and Research for Prevention (SHARP) program within L&I. Estimates of the workplace MSD hazard exposure levels were made at the one-digit and two digit industrial classification level. These estimates, combined with the OSHA control cost data, and other information and estimates on personnel time, allowed us to calculate total compliance cost for each element of the ergonomics rule. Elements of the ergonomics rule were primarily applied to the employee populations estimated to be in “caution zone jobs” and in jobs requiring control of hazards (WMSD hazard jobs).

Compliance costs were determined for the following rule elements:

- initial rule review- the initial time necessary for a business owner or manager to review the ergonomics rule and determine if applies to his/her business.
- job identification – a quick survey to determine if there is exposure to any of the listed ergonomic risk factors in a particular job at or above the caution zone specified in the rule.
- job analysis – more detailed analysis applied to caution zone jobs to determine if the WMSD hazard exposure is sufficient to qualify the job as a hazard job
- educational awareness – basic ergonomic education given to employees in caution zone jobs.
- hazard job training – training for a employee in a hazard job following reduction of the hazard exposure.
- training of the evaluator – a level of training for managers or supervisors conducting job analysis or hazard job training.
- engineering and administrative controls – steps taken to reduce the WMSD hazard in hazard jobs down to or below the caution zone hazard level.
- personal protective equipment – protective equipment to reduce the WMSD hazard in hazard jobs down to or below the caution zone hazard level. Considered inferior to engineering and administrative controls.
- managerial and administrative time – time required to oversee and evaluate a companies ergonomic program.

- The employee, manager/supervisor and consultant time requirements, timeline and expertise levels for completing the above elements are summarized in Table 1 below.

Table 1: Assumptions Utilized to Develop Costs for the Various Provisions of the Ergonomics Rule

Rule Provision	When applicable	Average hours involved	Level of expertise
Rule review-Initial management review	year 2-4, repeated every 3 years	small emp.: 2 hr large emp.: 6 hr	Manager/owner
Rule review-Presentation to safety committee (only applicable to companies with more than 10 employees)	year 2-4, repeated every 3 years	small emp.: 1 hr-1 manager, 2 employees large emp.: 1 hr-2 managers, 6 employees	Manager/owner and Employees
Job Identification	year 2-5	5 – 10 min. per job	Manager
Job Analysis	year 3-6	1-5 hr. depending on SIC. Manager or Ergonomics Specialist and 0.5 hr Employee time	80% Manager 20% Ergonomics Specialist
Awareness Education	year 3-6, recurring and repeated every 3 years	1 hr employee and instructor	Manager or Supervisor
Hazard Job Training	year 3-6, recurring as needed	1 hr. employee 2 hr. instructor	Manager or Supervisor
Training the evaluator	year 3-6, recurring as needed	12 hr class session \$250 class fee	Manager or Supervisor
Search for and Implementation of Ergonomic Control Measures	year 4-7, recurring	2-16 hours: employee 0-16 hours: supervisor 0-8 hours: consultant	Manager or Ergonomics Specialist
Program Management	year 1-7, repeated every year.	Small emp.: 6 hr/yr. Large emp.: 40 hr/yr.	Manager

Note that the department considers the time estimates for job identification, awareness education, hazard job training, and especially for training the evaluator and job analysis to be greater than required by the rule. Thus the department was conservative in its cost estimation.

Discounting and Annualization of Compliance Costs

Costs were annualized over 10 years for engineering and administrative controls as well as job identification and analysis and for hazard job training. Costs were annualized over

3 years for the ergonomic awareness education and 5 years for job review. Management costs were computed as recurring annual values. Because expenditures occurring in different years must be rendered comparable in terms of their units of value, economists employ the concept of a *discount rate*. The discount rate captures the fact that a dollar of expenditure today is not equivalent to a dollar of expenditure in the future due to the fact that money can earn interest for its owner. If the risk-free interest rate is r , one dollar today is equivalent in value to $(1+r)$ dollars a year from today. One approach to choosing the appropriate discount rate is to subtract the average inflation rate for the last several years (1.5 to 3%) from the average ten-year Treasury bill rate (6-7%). This yields a discount rate of 3 to 5 percent. Another approach is to use inflation-indexed ten-year Treasury bills, which currently have a rate of approximately 3.5 percent. In this analysis a conservative discount rate of 5 percent was used to discount future costs and benefits and to annualize the total costs and benefits. Because the proposed rule has a significant phase-in period many of the rule compliance costs will occur several years from now. Future costs were discounted in a manner that was consistent with the rule's phase-in schedule. The estimated rule compliance costs are presented as total cost, cost for each component of the rule, cost per employee, cost per affected employee (when different from cost per employee), cost per establishment, and cost as a percentage of GBI.

Employee turnover

Job and employee turnover were issues of concern in this analysis. Employee turnover for the state was approximated using results from the 1988 National Occupational Exposure Survey (NOES). The NOES employee turnover information was available at the one digit SIC level. Employee turnover ranged from 9 percent per year for SIC 4 to 31 per cent per year for SIC 0, with an average of 14 per cent. The turnover rate for supervisors and managers was assumed to be 14 percent per year. Job turnover refers to the year-to-year change in the mix of job types in the state due to technological change, or shifts in market conditions. Job turnover was not factored into the cost calculations for the following reasons: 1. In the short term we assume that the mix of jobs in Washington State would remain relatively constant. 2. Job or population growth is not anticipated to change the outcome of this analysis because the impact of the rule is assessed in the form of a benefit cost ratio (an increase in the working population would presumably have similar impacts on the benefits and costs of the rule).

Surveying Washington State Businesses

A mail survey undertaken by SHARP staff in the summer of 1998 was designed to obtain information on exposures of workers to risk factors for WMSDs (see Appendix A: Employer Ergo Survey, June 1998). This survey is referred to as Ergo Survey 1 throughout the remainder of this text. A sample of 10,000 Washington State employers was randomly selected from an administrative database, of which 6,540 were successfully contacted. Completed questionnaires were received from 4,906 businesses

across all industries and sizes, for a response rate of 75%. Firms were asked to report the number of workers exposed to each risk factor for less than 2 hours, 2-4 hours and for more than four hours. Results of the survey were analyzed and presented in Foley and Silverstein, 1999. Over 33.2% of respondents reported having had employees with WMSD injuries in the previous three years.

This source allowed us to estimate the proportion of the workforce in each industry that was exposed to each risk factor for more than four hours and for more than two hours. We call the entire workforce in a given SIC code the Level 1 population. In our analysis, we have assumed that the exposure of any worker at a firm to any risk factor for more than two hours (four or more hours for intensive keying work) constitutes a risk sufficient to require the firm to undertake job hazard analysis and to institute workforce education. Jobs with two or more hours of exposure are referred to as “caution zone jobs” and the entire population of these jobs is designated the Level 2 population. Exposure to the risk factors for four or more hours (seven or more hours for intensive keying) was assumed to trigger a requirement that the firm implement control measures. Jobs with four or more hours of exposure are referred to as “WMSD hazard jobs” and the entire population of these jobs is designated the Level 3 population. Because Ergo Survey 1 estimated risk factor exposures for zero hours, two or more hours and four or more hours we could not directly estimate the population of employees exposed to seven or more hours of intensive keying. Data used to estimate the seven-hour population came from a survey sponsored by the National Science Foundation for their 1998 report, *Science and Engineering Indicators*. This survey (Miller and Kimmel, 1997, and unpublished tabulations) revealed that the seven-hour population was 43 percent of the four-hour population. We utilized this ratio to adjust our estimate of the Level 3 keying populations.

To construct an estimate of the cost imposed by the ergonomics rule on Washington businesses a telephone survey was developed and administered by L&I in the summer of 1999 (see Appendix B: Telephone Survey, July 1999). This survey is referred to as Ergo Survey 2 throughout the remainder of this text. The survey elicited information from a sample of businesses across many industries. The survey contained questions about WMSD hazards, time and costs incurred to identify jobs with hazards, and implement ergonomic changes. If changes in jobs were made, employers provided information on costs of control strategies, and detailed information about programs, personnel and elements of engineering controls and training.

In order to ensure adequate coverage across all Washington industries, the sample of 5,644 businesses was drawn so that industries that had few firms and large businesses were over-represented. Prior to the survey, an informational mailing was sent to each of the businesses selected to participate (see Appendix C: Cover letter). The mailing alerted businesses that they would be asked to participate in a survey, advised them as to the exact nature of the occupational hazards they would be questioned about, and suggested the types of records they should consult to make the telephone interview proceed as

smoothly as possible. Employment and address information for each sampled firm was obtained from the 1998 Quarterly Unemployment Insurance file obtained from the Employment Security Department. Gilmore Research of Seattle conducted the phone survey. The interviews were completed for a total of 1,085 businesses out of a total of 4,425 firms successfully contacted, for a response rate of 24.5%.

From Ergo Survey 2, L&I obtained estimates on the proportion of employers already implementing controls that would be deemed sufficient under the proposed rule. Time and personnel requirements for certain elements of the Ergonomics rule were also estimated from Ergo Survey 2.

Estimating the fractions of workers exposed to WMSD hazards

In Ergo Survey 1 firms were asked to report the number of workers exposed to each of fifteen separate WMSD risk factors. Since the rule does not cover five of these risk factors, the calculation of workforce exposure to WMSD hazards is limited to the ten covered risk factors. To determine the fraction of the workforce exposed to *any or all of the risk factors* we had to combine the exposure fractions for each of the individual risk factors. The highest individual exposure fraction represents the lower bound estimate of the total exposure rate. This would be the case when all WMSD hazards were *clustered* amongst a particular subset of the workforce in a given industry. The upper-bound estimate would be the opposite case, where the sub-population exposed to the single largest individual risk factor was entirely distinct from the sub-populations exposed to each of the other risk factors. In this case the total exposed fraction would simply be the sum of the ten individual exposure fractions. This would reflect complete hazard *segregation* across the exposed sub-populations. Neither case is likely to be an accurate estimate of the true population exposure fraction. Instead the fractions of the workforce exposed to each individual risk factor are likely to overlap. This requires us to make an assumption as to the degree of this overlap. We assume that the degree of overlap between any two risk factors can be represented by the correlation between them. So if the correlation coefficient in a particular industry between awkward lifting and repetitive lifting were 0.5 we assume that 50% of the sub-population exposed to awkward lifting is also exposed to repetitive lifting. Since the rule requires the firm to act whenever a job exceeds critical thresholds for *one or more* risk factors, we include only the non-overlapping fractions of the workforce when calculating overall exposure. Therefore, in order to avoid double-counting when deriving total exposure, we exclude the portion of the sub-population exposed to repetitive lifting that is *also* exposed to awkward lifting. The fraction of the workforce in each two-digit SIC industry that is exposed to one or more risk factors is calculated as follows:

$$W = RF_m + \sum_i \max \left\{ 0, \left[(1 - r_{mi}) \cdot \left(RF_i - \sum_k (r_{ki} \cdot RF_k) \right) \right] \right\}$$

for $i \neq m, \quad k \neq m, \quad k \neq i$

Where W is the fraction of the workforce exposed to one or more WMSD risk factors above the critical threshold, RF_m is the single largest individual workforce exposure in a given industry, and RF_i and RF_k are the fractions of the workforce exposed to other risk factors. The correlation coefficients between the predominant risk factor m and risk factors i and k are represented by r_{mi} and r_{ki} , respectively. Each RF is calculated as the number of employees exposed to the risk factor above the critical threshold, divided by full-time equivalent (FTE) employment in that industry. Because the survey data did not permit us to adjust the number of exposed workers to the FTE equivalent, the total exposure fraction, W , is somewhat *overestimated* by this procedure. Therefore, business costs of compliance will also be slightly overestimated by this method. The extent of this bias is probably quite small, however. For two-digit SIC industries with less than three firms responding to the survey we used the overall average exposure fraction for the one-digit SIC industry division to which that industry belongs.

Upper and Lower Confidence Intervals

For each one-digit SIC industry division, intervals were calculated around these exposure estimates such that there is a 95% degree of confidence that the true population fractions lie within the upper and lower bounds of these intervals. It should be noted that the use of the 95% level of confidence results in wider intervals than would be the case for estimates with less confidence. But given the importance of this step for the calculation of costs and benefits, together with the wide variation in exposure levels from industry to industry and the potential for estimation error due to sample size, it was thought best to be especially cautious in making exposure estimates. These upper and lower bound estimates of the workforce exposed to one or more WMSD hazards, together with the central estimate, are shown in Appendix D.

Presentation of Cost Results

For each one-digit SIC, estimates of the total workforce exposure to WMSD risks for 2 or more hours and 4 or more hours were made, corresponding to the Level 2 and Level 3 populations. Throughout this analysis calculations were done at the 2-digit SIC industry level, although the tables in this document aggregate these results at the 1-digit industry division level. To ensure that this is an appropriate level of aggregation, an analysis of all three-digit SIC sub-components of each 2-digit SIC industry was performed. A team of five professional ergonomists reviewed each 2- and 3-digit SIC code by occupation and

process to determine where there were similarities and differences in exposures and solutions to potential hazards for WMSDs. Two data sources were used: 1998 Washington State Occupation Tables, provided by the Employment Security Department, which provide the percent of total employment by occupation in each 2- and 3-digit SIC; and data from the 1993 OSHA Employer Ergonomics Survey, which lists the major processes by SIC. Based on review of case studies, consultant reports and expert judgment, the ergonomists summarized the information available by 2-digit SIC. Cost data for 2-digit SIC industries are reported in Appendix E.

The Level 2 and 3 population estimates were derived from Ergo Survey 1. These were combined with the job identification, job analysis and training times, and personnel requirements estimates derived from the Ergo Survey 2 and the per-employee control cost data from OSHA to estimate the total cost to Washington State businesses for the Proposed Ergonomics Rule.

The populations potentially affected by the Proposed Ergonomics Rule were estimated using the techniques described in the methods section. Total workforce population (Level 1), “caution zone jobs” population (Level 2) and WMSD hazard job populations (Level 3) are presented by one digit SIC in Table 2 below. Note that workforce numbers represent full time equivalents (FTEs) and exclude sole proprietorship businesses.

Table 2: Level 1, 2 and 3 Workforce Populations- Full Time Equivalents

SIC		LEVEL 1 POP.			LEVEL 2 POP.		LEVEL 3 POP.	
0	Agriculture, Forestry and Fishing	45,275	29,461	74,737	14,432	6,253	12,092	5,734
		<i>10,816</i>	<i>211</i>	<i>11,027</i>				
1	Mining and Construction	73,001	35,130	108,132	22,600	11,585	13,630	9,318
		<i>17,359</i>	<i>322</i>	<i>17,681</i>				
2	Manufacturing, nondurables	27,950	106,269	134,219	7,267	19,817	6,008	14,492
		<i>3,695</i>	<i>447</i>	<i>4,142</i>				
3	Manufacturing, durables	28,786	209,467	238,253	6,639	146,936	4,300	63,822
		<i>3,143</i>	<i>513</i>	<i>3,656</i>				
4	Transportation, and public utilities	28,682	126,451	155,133	7,492	53,650	4,265	26,314
		<i>5,012</i>	<i>379</i>	<i>5,391</i>				
5	Wholesale and retail trade	188,819	302,923	491,742	39,332	128,095	21,294	73,514
		<i>32,892</i>	<i>1,356</i>	<i>34,248</i>				
6	Finance, insurance and real estate	36,484	74,739	111,223	8,068	16,869	4,538	7,204
		<i>9,612</i>	<i>350</i>	<i>9,962</i>				
7	General services	84,535	121,562	206,097	17,670	39,350	9,324	20,848
		<i>17,719</i>	<i>625</i>	<i>18,344</i>				
8	Professional services	127,317	349,142	476,459	28,954	75,474	14,857	40,281
		<i>45,556</i>	<i>1,146</i>	<i>46,702</i>				
9	Public administration	5,976	127,517	133,493	2,073	46,314	436	6,771
		<i>606</i>	<i>247</i>	<i>853</i>				
SUM		646,825	1,482,891	2,129,716	154,526	544,342	90,743	268,297
		<i>146,410</i>	<i>5,596</i>	<i>152,006</i>				

Values in italics are number of establishments

Compensation rates

Unit labor compensation rates (total cost for an hour of work, also known as hourly wage) were estimated for the persons identified in Ergo Survey 2 as being responsible for identifying caution zone jobs, performing hazard analysis and ergonomics education or training as well as managing ergonomics programs. If survey respondents indicated that they had more than one person conducting identification, analysis, training and program management functions, the costs were averaged within company. Unit labor compensation rates were considered to be composed of the hourly wage rate and associated fringe benefits. Average hourly wage rates for the ten one digit SIC categories and the fourteen occupation categories utilized in Ergo Survey 2 were obtained from the U.S. Bureau of Labor Statistics and from the Washington State Employment Security Department and the Department of Personnel. Fringe benefits ranged from 13 to 47 percent of the hourly wage and had a weighted average of 36 percent (U.S. Bureau of Labor Statistics). Because compensation rates for three occupation categories in the survey could not be readily obtained, the following assumptions were made: owners were assumed to be compensated at 200% of industry average rates, managers 150%, and supervisors 125% of industry average rates. Average hourly wage rates, fringe benefits and total hourly compensation are presented at the one digit SIC level in Table 2 below.

Table 3: Wage Compensation and Fringe Benefits

SIC	Average Hourly Wage Compensation	Fringe Benefits (%)	Average Total Compensation
0	\$7.39	15%	\$8.48
1	\$21.25	40%	\$29.84
2	\$19.58	42%	\$27.84
3	\$21.58	47%	\$31.79
4	\$18.56	45%	\$26.82
5	\$17.62	30%	\$22.82
6	\$18.02	41%	\$25.41
7	\$14.88	33%	\$19.71
8	\$13.11	33%	\$17.38
9	\$20.00	42%	\$28.32
Overall	\$16.98	36%	\$23.05

A measure of wage dispersion was calculated using the 1998 Washington State Population Survey. Respondents to that survey provided information about employment, earnings and type of business for large and small establishments. The results of wage tabulations indicated that across all industries small businesses paid their managers and supervisors 15 percent less than large businesses. To adjust for wage dispersion the estimated wages for owners, managers and supervisors from small businesses was adjusted downward by 7.5 percent, while the wage rate for similar job categories in large businesses was adjusted upward by 7.5 percent. Wage dispersion data for non-supervisory jobs revealed that overall pay for similar jobs in small business was 24 percent lower than in large business. However, the wage dispersion data were not utilized for non-supervisory wages. By not applying the wage dispersion data, small businesses costs for certain components of the rule are inflated relative to large business costs. Adjusted average unit labor rates for supervisory personnel grouped by one digit SIC are shown in Table 4 below.

Table 4: Average Unit Labor Costs Associated With Components of the Ergonomics Rule.

SIC	INDUSTRY TITLE	Identification step		Analysis step		Ergonomics Training		Program mngmt	
		Small	Large	Small	Large	Small	Large	Small	Large
0	Agriculture, Forestry & Fishing	\$16.73	\$21.17	\$17.17	\$22.51	\$17.96	\$21.72	\$17.83	\$24.87
1	Mining and Construction	\$37.65	\$33.03	\$36.60	\$27.80	\$38.86	\$34.91	\$37.83	\$36.30
2	Manufacturing, nondurables	\$29.45	\$32.68	\$29.40	\$32.19	\$31.69	\$31.95	\$32.63	\$33.01
3	Manufacturing, durables	\$34.67	\$34.01	\$33.67	\$32.79	\$37.91	\$36.48	\$36.31	\$34.57
4	Transportation & public utilities	\$32.73	\$32.33	\$30.34	\$32.57	\$36.87	\$37.71	\$36.29	\$37.71
5	Wholesale and retail trade	\$26.96	\$26.59	\$27.99	\$25.26	\$28.12	\$25.39	\$27.74	\$25.68
6	Finance, insurance & real estate	\$32.43	\$23.01	\$34.50	\$29.27	\$34.53	\$32.04	\$35.68	\$22.24
7	General services	\$33.65	\$31.76	\$34.66	\$34.84	\$36.64	\$29.12	\$35.46	\$29.31
8	Professional services	\$29.85	\$27.34	\$26.45	\$30.21	\$34.59	\$31.88	\$31.47	\$34.76
9	Public administration	\$22.62	\$27.91	\$17.05	\$26.88	\$30.44	\$21.91	\$28.73	\$25.40
TOTAL		\$30.26	\$29.73	\$29.99	\$29.87	\$32.82	\$31.10	\$31.88	\$31.15

The average unit labor rates for those responsible for conducting identification, hazard analysis, training and ergonomic program management functions, were found to be roughly the same for large and small businesses. Many of the small business respondents to Ergo Survey 2 indicated that they had used or planned to use a consultant to perform various components of an ergonomics program. It is the department's belief that, in general, consultants (and their associated higher unit labor cost) will not be necessary for compliance with this rule. We did not attempt to correct the small business unit labor rates for the higher consultant labor rate embedded within the overall rate.

Control cost information

Engineering and administrative control costs necessary to achieve an acceptable degree of WMSD hazard reduction were taken primarily from the 1999 OSHA publication:

Preliminary Economic Analysis and Initial Regulatory Flexibility Analysis for the OSHA Proposed Ergonomics Program Standard (referred to from here on as the OSHA Preliminary Economic Analysis). Engineering and administrative control costs for businesses in SIC 0 and 1 were taken from for OSHA's 1995 Preliminary Regulatory Impact Analysis (PRIA). The basic information used to estimate engineering and administrative control costs was developed for OSHA's 1995 PRIA. Ergonomists developed information (including ergonomic solutions) for OSHA on 170 workplace scenarios that had significant ergonomic problems. OSHA then characterized the jobs reflected in each scenario as belonging to one of 26 broad occupational groupings. Costs were then estimated for each occupational grouping. OSHA used its own ergonomic employer survey to estimate the number of workers in each occupational grouping at the three digit SIC level. Engineering and control costs were presented on a per job basis, per employee basis, per establishment basis and by each major industry. The 1999 OSHA draft proposal economic analysis strategy was reviewed by a group of economists from several universities. An expert ergonomist panel recently convened by OSHA reviewed and updated the 1995 engineering and administrative control cost estimates for use in OSHA's 1999 Preliminary Economic Analysis.² At this time the Preliminary Economic Analysis constitutes the most comprehensive evidence on ergonomic control costs. For this analysis it was assumed that each employee in a WMSD hazard job represented one job that had to be fixed. Because workers are frequently employed in shift type work they often share the same work-site or workstations. Thus, by equating the reported number of employees in hazardous jobs (determined from Ergo Survey 1) with work-site or workstations that will require hazard reduction, L&I is slightly overestimating the fixes required. The OSHA control cost data was multiplied by the Department of Labor and Industries' estimates of the Level 3 population for each industrial category.

Search and Implementation Costs for Control Equipment

After the employer has identified WMSD hazards in a job, he or she must determine the control solution that will reduce the hazard to an acceptable level. The process of selecting the hazard control solution will require some search time by the employer, employees and possibly some input from a consultant. After selecting the control solution the employer and employees will need to set aside time to implement the controls. The department has estimated the following average personnel and time inputs for the search and implementation step for large and small businesses.

² Because many of the solutions to workplace WMSD hazards result in increase productivity the expert ergonomist panel added productivity offsets for the control solution costs. In addition a significant amount of additional time was allowed for businesses to search for and implement the ergonomic control solutions.

Table 5: Time and Personnel Requirements for Search and Implementation Step

Grouping Category	Fraction jobs		Time requirements		
	Small	Large	Employee	Manager or Supervisor	Consultant
A	0.75	0.50	2	2	0
B	0.25	0.35	8	8	0
C	0.05	0.15	16	16	8

For large businesses the department believes that for 50 percent of hazard jobs (category A) the control solution search and implementation can be achieved with 2 hours of employee and 2 hours of manager time. Another 35 percent of hazard jobs (category B) will require more search and implementation time, 8 hours employee and 8 hours manager time, but can still be done without the aid of a consultant. The department believes that at most 15 percent of hazard jobs at large businesses will require search and implementation assistance from a consultant: category C, 16 hours employee and manager time and 8 hours of consultant time. Because of the rule phase-in the department believes that standard solutions will emerge for most types of hazard jobs and that the more time intensive grouping categories B and C will be reduced for small businesses. A composite cost for search and implementation time per hazard job was derived for large and small businesses based on the time and personnel requirements in the above table and the hourly compensation rates presented in tables 3 and 4. A value of 75 dollars per hour was used as the compensation rate for consultants. Average search and implementation costs were included as part of the control costs for hazard jobs.

B. Rule Compliance Costs

1. Rule Review Costs

The department projects that there will be costs for both the time it takes employers to initially become familiar with the proposed ergonomics rule and the time required to present the rule to their company safety committees (businesses with 11 or more employees only). The time for rule review was 2 hours for small businesses and 6 hours for large businesses³. An additional hour was allowed for presentation to company safety committees. These costs are anticipated to be one-time expenditures, and will occur over the first four years of the rule phase-in period. As a conservative measure costs were

³ Rule review time was doubled from the estimates presented in the SBEIS document.

annualized over 5 years (rule review is repeated every 5 years) at a 5% discount rate. Rule review costs are presented in Table 6 below with total annualized cost estimated at \$ 4.28 million and per employee and per establishment costs at \$2.01 and \$28.18 respectively.

It should be noted that because the number of responses the Department received from the Public Administration sector was low we believed them to be too unreliable to use as a basis to estimate true costs of compliance for that sector. Accordingly we have used the *overall* compliance cost per employee to represent costs for this sector. This is appropriate given the fact that the Public Administration sector comprises a broad mixture of occupations and workplaces, from services to office work to construction activities. The effect of this substitution is to increase the overall estimated cost of compliance for the rule.

Table 6: Estimated Rule Review Cost

SIC	INDUSTRY TITLE	Estimated Total Rule Review Costs	Cost per employee,	Cost per establishment
0	Agriculture, Forestry and Fishing	\$159,260	\$2.13	\$14.44
1	Mining and Construction	\$603,801	\$5.58	\$34.15
2	Manufacturing-nondurables	\$146,123	\$1.09	\$35.28
3	Manufacturing-durables	\$154,577	\$0.65	\$42.28
4	Transportation and Public Utilities	\$174,210	\$1.12	\$32.32
5	Wholesale and Retail Trade	\$816,877	\$1.66	\$23.85
6	Finance, Insurance and Real Estate	\$272,956	\$2.45	\$27.40
7	General Services	\$523,830	\$2.54	\$28.56
8	Professional Services	\$1,176,312	\$2.47	\$25.19
9	Public Administration	\$255,409	\$1.91	\$299.42
SUM		\$4,283,356	\$2.01	\$28.18

Annualized 5%, 5 yrs

Small business 2 hr review

Large business 6 hr review

2. Estimated Costs for Identifying “Caution Zone Jobs”.

The department anticipates that most businesses will carry out an identification, or screening, step to determine if a particular job might be a “caution zone job”. The estimated costs for the identification step were based on the following assumptions. All businesses are covered by the proposed rule and would potentially do this identification step. However, results from Ergo Survey 1 indicate that approximately 10 percent of small businesses and 1.4 percent of large businesses have no jobs with ergonomic risk factors and as a consequence will not need to undertake the identification or any subsequent steps. In addition results from Ergo Survey 2 indicated that many businesses have already undertaken some type of job identification step, 16 percent of small businesses, and 51 percent of large businesses, on their own and therefore will experience only minimal new costs due to the proposed rule. For those that need to undertake the identification step it was assumed that the time necessary for this step was 5 minutes per job. The department believes that this is a conservative time estimate and that most jobs can be processed in less than 5 minutes. For instance many workplaces have classes of jobs where similar tasks are performed, in which case the identification step for one job would suffice for the entire class of jobs. For businesses in SIC 1, an identification time of 10 minutes per job was utilized. To estimate identification step costs the supervisory unit wage costs (1 hour of time by SIC) presented in Table 2 above were multiplied by the number of jobs estimated to require the identification step then by 0.0833 hours (5 minutes). For each small business establishment an additional 20 minutes of time was added for compiling the job identification results. For each large establishment an hour of compilation time was added. Costs were annualized over ten years at a 5 percent discount rate. Table 7 reveals the estimated costs for the identification step for all businesses in Washington State. The total annualized cost for businesses to identify caution zone jobs was estimated at \$597 thousand. On a per employee basis the average annual identification costs are estimated to be \$ 0.28, while the average annualized cost for a business establishment was \$ 3.93.

Table 7: Estimated Job Identification Cost

SIC	INDUSTRY TITLE	Estimated Washington State Ergonomic Job Identification Costs	Cost per employee	Cost per establishment
0	Agriculture, Forestry and Fishing	\$20,112	\$0.27	\$1.82
1	Mining and Construction	\$99,065	\$0.92	\$5.60
2	Manufacturing-nondurables	\$49,646	\$0.37	\$11.99
3	Manufacturing-durables	\$31,784	\$0.13	\$8.69
4	Transportation and Public Utilities	\$50,250	\$0.32	\$9.32
5	Wholesale and Retail Trade	\$49,171	\$0.10	\$1.44
6	Finance, Insurance and Real Estate	\$38,590	\$0.35	\$3.87
7	General Services	\$84,247	\$0.41	\$4.59
8	Professional Services	\$138,261	\$0.29	\$2.96
9	Public Administration	\$36,105	\$0.27	\$42.33
SUM		\$597,232	\$0.28	\$3.93

Annualized 5%, 10 yrs

Global 5-10 min. ID time, adj for existing ergonomics programs

3. Estimated Costs for Hazard Analysis of “Caution Zone Jobs.”

If a “caution zone job” is found in the identification step of workplace analysis, then a more detailed hazard analysis must be performed to fully assess the type(s), severity and causes of the WMSD hazards. The following assumptions were made to determine the cost to large and small businesses for the hazard analysis step. The number and distribution of “caution zone jobs” (Level 2 jobs) was estimated using the results of Ergo Survey 1 and were presented in Table 1.

Because many businesses have conducted hazard analysis, the number of “caution zone jobs” requiring analysis is actually smaller than the Level 2 population reported in Table 1. The actual fraction of employers needing to conduct hazard analysis was estimated using responses to Ergo Survey 2 questions and was applied to the Level 2 population numbers. Analysis time was estimated from the Department’s Ergo Survey 2, with the minimum analysis time being 60 minutes. In addition hazard analysis was assumed to require 30 minutes of time of the employee performing the job or tasks. Two final assumptions were made that for 20 percent of jobs a consultant would be hired and for 25 percent of the caution zone jobs the nature of and solutions for the WMSD hazards would

be readily apparent and therefore a detailed hazard analysis step would not be required⁴. Costs were annualized over 10 years at 5 percent. Total annualized costs of hazard analysis were approximately \$3.62 million. The annualized costs per employee, per affected employee and per establishment for this component of the rule are \$ 1.70, \$5.18 and \$23.80 respectively. Results at the one digit SIC level are shown in Table 8.

Table 8: Estimated Job Analysis Costs

SIC	INDUSTRY TITLE	Estimated Total Job Analysis Costs	Cost per employee	Cost per affected employee	Cost per establishment
0	Agriculture, Forestry and Fishing	\$61,749	\$0.83	\$2.99	\$5.60
1	Mining and Construction	\$291,416	\$2.70	\$8.52	\$16.48
2	Manufacturing, nondurables	\$379,824	\$2.83	\$14.02	\$91.70
3	Manufacturing, durables	\$260,515	\$1.09	\$1.70	\$71.26
4	Transportation and public utilities	\$1,265,135	\$8.16	\$20.69	\$234.68
5	Wholesale and retail trade	\$139,527	\$0.28	\$0.83	\$4.07
6	Finance, insurance and real estate	\$107,370	\$0.97	\$4.31	\$10.78
7	General services	\$311,710	\$1.51	\$5.47	\$16.99
8	Professional services	\$581,789	\$1.22	\$5.57	\$12.46
9	Public administration	\$219,304	\$1.64	\$4.53	\$257.10
SUM		\$3,618,338	\$1.70	\$5.18	\$23.80

Annualized 5%, 10 yrs

4. Estimated Engineering and Administrative Control Costs

Jobs that are identified as having WMSD hazards in the hazard analysis step will require control measures. Engineering and administrative controls are two approaches to controlling WMSD hazards in the workplace. Engineering and administrative control costs for large and small businesses were estimated using the following assumptions. The number of WMSD hazard jobs, which is represented by the Level 3 population (see Table 1), was determined using information from Ergo Survey 1. Engineering and Administrative Control costs on a per employee basis were estimated using data from two

⁴ Consultant time and associated cost for job hazard analysis was not part of the SBEIS cost methodology. The rapid solution fraction was decreased from 30 to 25 percent.

OSHA documents: 1999 Preliminary Economic Analysis and the 1995 Preliminary Regulatory Impact Analysis. The estimated control costs were converted to 1998 dollars and multiplied by the number of WMSD hazard jobs. Total annualized engineering and administrative control costs were estimated to be approximately \$53.5 million. Annualized per employee and per establishment costs were \$25.1 and \$352 respectively. Cost per affected employee (total annualized cost divided by the number of full-time workers in hazard jobs) was determined to be \$149. Results at the one digit SIC level are shown in Table 9 below.

Table 9: Estimated Engineering, Administrative Control Costs

SIC	INDUSTRY TITLE	Estimated Engineering and Administrative Control Costs	Cost per employee,	Cost per affected employee	Cost per establishment
0	Agriculture, Forestry and Fishing	\$3,823,469	\$51.2	\$214.5	\$346.7
1	Mining and Construction	\$10,795,872	\$99.8	\$470.5	\$610.6
2	Manufacturing, nondurables	\$2,557,259	\$19.1	\$124.7	\$617.4
3	Manufacturing, durables	\$8,711,879	\$36.6	\$127.9	\$2,382.9
4	Transportation and public utilities	\$5,770,604	\$37.2	\$188.7	\$1,070.4
5	Wholesale and retail trade	\$9,896,560	\$20.1	\$104.4	\$289.0
6	Finance, insurance and real estate	\$902,248	\$8.1	\$76.8	\$90.6
7	General services	\$2,999,494	\$14.6	\$99.4	\$163.5
8	Professional services	\$4,813,812	\$10.1	\$87.3	\$103.1
9	Public administration	\$3,195,954	\$23.9	\$443.5	\$3,746.7
SUM		\$53,467,151	\$25.1	\$148.9	\$351.7

Source: OSHA PEA 1999 and OSHA PRIA 1995
1998 dollars

It should be noted here that these control cost estimates are based upon present technological capabilities and therefore ignore the effect of technological innovation in reducing those costs in response to the standard (Ashford, 1997). A recent study of OSHA's estimates of economic impact of proposed regulations found that the agency had "devote[d] relatively little attention to examining the potential of advanced technologies or the prospect of regulation-induced innovation to provide technologically and *economically* superior options for hazard control (emphasis added)".⁵ The effect of this conservatism on the part of OSHA was to significantly overestimate the compliance costs, which the Office of Technology Assessment found were actually expended by industry once the regulation was in place. One example is that costs to retrofit existing

⁵ U.S.Congress, Office of Technology Assessment, *Gauging Control Technology and Regulatory Impacts in Occupational Safety and Health—An Appraisal of OSHA's Analytic Approach*, (1995, Chap. 1, p.11.)

equipment are frequently higher than when existing equipment wears out and is replaced with new equipment with the hazard control technology designed in. Apart from ignoring innovation, compliance costs are often overestimated by failing to account for scale economies in the production of control technologies. Once a standard is adopted, a market arises for control technologies, including hazard identification measures and training materials. The increase in production of these materials frequently reduces their unit costs. Finally, cost estimates such as those made in this document ignore the ability of industry to learn over time how to comply more cost-effectively (Ashford, 1997).

5. Estimated Cost for Personal Protective Equipment

A secondary approach for controlling workplace WMSD hazards is to use Personal Protective Equipment (PPE). The technique for estimating PPE costs was similar to that for engineering and administrative Controls costs above. The PPE costs, on a per employee basis, were derived from the 1995 OSHA PRIA then multiplied times the number of WMSD Hazard jobs in Washington state. The annualized PPE costs for all business was \$661 thousand. Average annualized costs per employee and per establishment were \$0.31 and \$4.35 respectively: note the PPE per employee costs are low because they are inexpensive and much less effective ergonomic control measure- and therefore not a valid control technique. Cost per affected employee was determined to be \$1.84. See Table 10 for details.

Table 10: Estimated PPE Control Costs

SIC	INDUSTRY TITLE	Estimated Total Annual PPE Control Costs	Cost per employee,	Cost per affected employee	Cost per establishment
0	Agriculture, Forestry and Fishing	\$5,075	\$0.07	\$0.28	\$0.46
1	Mining and Construction	\$11,107	\$0.10	\$0.48	\$0.63
2	Manufacturing, nondurables	\$14,478	\$0.11	\$0.71	\$3.50
3	Manufacturing, durables	\$41,334	\$0.17	\$0.61	\$11.31
4	Transportation and public utilities	\$109,630	\$0.71	\$3.59	\$20.34
5	Wholesale and retail trade	\$113,158	\$0.23	\$1.19	\$3.30
6	Finance, insurance and real estate	\$56,483	\$0.51	\$4.81	\$5.67
7	General services	\$86,099	\$0.42	\$2.85	\$4.69
8	Professional services	\$184,002	\$0.39	\$3.34	\$3.94
9	Public administration	\$40,117	\$0.30	\$5.57	\$47.03
SUM		\$661,482	\$0.31	\$1.84	\$4.35

Costs annualized and adjusted to 1998 dollars

Source: OSHA PRIA, 1995

6. Estimated Cost for Basic Awareness Education

Employers with “caution zone jobs” (Level 2 population in Table 2) must provide basic ergonomic awareness education. The following assumptions were made when estimating these costs: there are two cost components to awareness education, the first corresponding to the time that the employee had to spend in the educational session and the other to the time the instructor committed to the session. Basic awareness education sessions were conservatively assumed to be one hour in length for employees and for the session instructor (manager, supervisor, etc.)⁶. The cost for the employee component of awareness education was determined by multiplying the estimated number of “caution zone jobs” in a given SIC category by the average hourly wage in that SIC multiplied by one hour. A cost of one dollar per employee was added to cover costs for copying and assembling the session handouts. To estimate the cost for instructor time in providing the educational session, the department assumed an average educational session size of four for small businesses, and twenty for large businesses. Total number of “caution zone jobs” for large and small businesses within a particular SIC were then divided by the corresponding average session size to arrive at the number of sessions required. The number of sessions was then multiplied by the instructor unit wage rates, from Table 2, to determine costs. Costs were adjusted for employee turnover using results from the National Occupational Exposure Survey (1988). Total costs were annualized over three years at 5 percent. Total annualized cost for awareness education was estimated to be \$7.23 million for all businesses. The average annualized per employee and per establishment costs were \$3.40 and \$47.59 respectively: see Table 11 for details.

⁶ Educational awareness times were increased from 40 minutes in the SBEIS cost analysis document.

Table 11: Estimated Awareness Education Costs

SIC	INDUSTRY TITLE	Estimated Basic Awareness Education Costs	Cost per employee	Cost per affected employee	Cost per establishment
0	Agriculture, Forestry and Fishing	\$144,938	\$1.94	\$7.01	\$13.14
1	Mining and Construction	\$520,504	\$4.81	\$15.23	\$29.44
2	Manufacturing, nondurables	\$180,082	\$1.34	\$6.65	\$43.48
3	Manufacturing, durables	\$1,522,777	\$6.39	\$9.92	\$416.51
4	Transportation and public utilities	\$614,524	\$3.96	\$10.05	\$113.99
5	Wholesale and retail trade	\$1,783,022	\$3.63	\$10.65	\$52.06
6	Finance, insurance and real estate	\$323,086	\$2.90	\$12.96	\$32.43
7	General services	\$705,673	\$3.42	\$12.38	\$38.47
8	Professional services	\$984,939	\$2.07	\$9.43	\$21.09
9	Public administration	\$454,655	\$3.41	\$9.40	\$533.01
SUM		\$7,234,198	\$3.40	\$10.35	\$47.59

1 hr. emp time and supervisor time

Small: 4 per class, Large: 20 per class

7. Estimated Cost for Hazardous Job Training

Employers must provide hazardous job training for those employees working in jobs identified as WMSD hazard jobs. As with the basic awareness education, there are two components to the total cost: the cost for employee training time and the cost for instructor time. The assumptions used to make this cost estimate were that hazardous job training sessions required 1 hour of employee time and 1 hour of manager or supervisor time⁷. Small businesses training sessions were estimated to have two employees, while large businesses had ten employees per session. As with awareness education a cost of one dollar per employee was assessed for copying and assembling training session handouts. Costs were adjusted for job turnover. Hazard job training costs were estimated at \$1.45 million for businesses. Average annualized costs per employee and per establishment were \$0.68 and \$9.54 respectively: see Table 12 for detailed results.

⁷ Instructor time was reduced from 2 hours in the SBEIS; annualization period changed to 10 years.

Table 12: Estimated Hazardous Job Training Costs

SIC	INDUSTRY TITLE	Estimated Hazardous Job Training Costs	Cost per employee	Cost per affected employee	Cost per establishment
0	Agriculture, Forestry and Fishing	\$35,036	\$0.47	\$1.97	\$3.18
1	Mining and Construction	\$93,307	\$0.86	\$4.07	\$5.28
2	Manufacturing, nondurables	\$237,179	\$1.77	\$11.57	\$57.26
3	Manufacturing, durables	\$283,660	\$1.19	\$4.16	\$77.59
4	Transportation and public utilities	\$87,351	\$0.56	\$2.86	\$16.20
5	Wholesale and retail trade	\$344,492	\$0.70	\$3.63	\$10.06
6	Finance, insurance and real estate	\$40,633	\$0.37	\$3.46	\$4.08
7	General services	\$96,205	\$0.47	\$3.19	\$5.24
8	Professional services	\$145,693	\$0.31	\$2.64	\$3.12
9	Public administration	\$86,919	\$0.65	\$12.06	\$101.90
SUM		\$1,450,476	\$0.68	\$4.04	\$9.54

1 hr emp training 1 hr supervisor time

Small: 3 per session Large: 12 per session

8. Estimated Cost for Training Job Analysts and Trainers

For those businesses conducting job analysis and hazard job training sessions a moderate level of additional training will be necessary for those conducting the job analysis or training sessions. Note the training of job analysts and trainers is not specifically required by the rule. The costs for training the trainer and the job analyst were made using the following assumptions. For small businesses it was assumed that one person required training for every three WMSD hazard jobs, for large businesses one person was trained for every twelve such employees. Training sessions were assumed to take 12 hours of employee time and cost \$250. Costs were adjusted for job turnover. Training costs were annualized over 10 years at 5 percent. The total annualized training costs were estimated to be \$3.56 million. Average costs per employee and per establishment were \$1.67 and \$23.39 respectively. Table 13 below summarizes the results.

Table 13: Estimated Costs for Training Job Analysts and Job Trainer

SIC	INDUSTRY TITLE	Training the Trainer Costs	Cost per employee	Cost per affected employee	Cost per establishment
0	Agriculture, Forestry and Fishing	\$223,809	\$2.99	\$12.56	\$20.30
1	Mining and Construction	\$390,866	\$3.61	\$17.03	\$22.11
2	Manufacturing, nondurables	\$206,933	\$1.54	\$10.09	\$49.96
3	Manufacturing, durables	\$478,873	\$2.01	\$7.03	\$130.98
4	Transportation and public utilities	\$258,033	\$1.66	\$8.44	\$47.86
5	Wholesale and retail trade	\$766,936	\$1.56	\$8.09	\$22.39
6	Finance, insurance and real estate	\$138,617	\$1.25	\$11.81	\$13.91
7	General services	\$319,394	\$1.55	\$10.59	\$17.41
8	Professional services	\$562,279	\$1.18	\$10.20	\$12.04
9	Public administration	\$209,943	\$1.57	\$29.13	\$246.12
SUM		\$3,555,684	\$1.67	\$9.90	\$23.39

12 hr training class, cost \$250

Small: 1 trained per 3 Level 2 or 3 emp

Large: 1 trained per 12 Level 2 or 3 emp

9. Estimated Managerial and Administrative Costs.

The department believes that businesses will require a small amount of manager and supervisor time to oversee and evaluate the company's ergonomics program. A substantial amount of managerial time has already been apportioned to the individual steps for rule review, caution zone job identification and analysis, search and implementation for hazard reductions, awareness education and hazard training. The time allotted for this step is only for oversight and evaluation of the company program. The department assumes that this step can be accomplished in 6 hours for small businesses and 40 hours for large businesses⁸. Total annualized managerial and administrative costs were estimated to be \$5.58 million for all businesses. Average costs per employee and per establishment were \$2.62 and \$36.70 respectively. Table 14 summarizes the estimated managerial costs.

⁸ Percent of manager time estimates replaced with hours per task estimates

Table 14: Management and Administrative Costs

SIC	INDUSTRY TITLE	Management and Administrative Costs	Cost per employee,	Cost per establishment
0	Agriculture, Forestry and Fishing	\$252,140	\$3.37	\$22.87
1	Mining and Construction	\$940,814	\$8.70	\$53.21
2	Manufacturing, nondurables	\$188,738	\$1.41	\$45.57
3	Manufacturing, durables	\$350,837	\$1.47	\$95.96
4	Transportation and public utilities	\$338,871	\$2.18	\$62.86
5	Wholesale and retail trade	\$974,907	\$1.98	\$28.47
6	Finance, insurance and real estate	\$270,895	\$2.44	\$27.19
7	General services	\$628,500	\$3.05	\$34.26
8	Professional services	\$1,303,917	\$2.74	\$27.92
9	Public administration	\$328,956	\$2.46	\$385.65
SUM		\$5,578,575	\$2.62	\$36.70

Small firms: 6 hrs/yr

Large firms: 40 hrs/yr

10. Total Estimated Costs and Per Employee Costs

Total costs for the proposed rule were estimated by combining the nine cost sub-components presented above. The estimated total annualized present value cost for the ergonomics rule is \$80.4 million. For reasons given above these total cost numbers should be considered generous estimates and probably overstate the true cost of the proposed rule. Average costs per employee and per establishment were \$37.77 and \$529 respectively. Detailed results on the annualized total costs are presented in Table 15 below.

Table 15: Total Estimated Costs and Cost per Employee

SIC	INDUSTRY TITLE	Total Estimated Ergonomics Rule Cost	Cost per Employee	Cost per establishment
0	Agriculture, Forestry and Fishing	\$4,725,588	\$63.23	\$428.55
1	Mining and Construction	\$13,746,752	\$127.13	\$777.49
2	Manufacturing, nondurables	\$3,960,261	\$29.51	\$956.12
3	Manufacturing, durables	\$11,836,237	\$49.68	\$3,237.48
4	Transportation and public utilities	\$8,668,608	\$55.88	\$1,607.98
5	Wholesale and retail trade	\$14,884,649	\$30.27	\$434.61
6	Finance, insurance and real estate	\$2,150,878	\$19.34	\$215.91
7	General services	\$5,755,152	\$27.92	\$313.73
8	Professional services	\$9,891,003	\$20.76	\$211.79
9	Public administration	\$4,827,362	\$36.16	\$5,659.28
SUM		\$80,446,490	\$37.77	\$529.23

Costs are annualized and expressed in 1998 dollars

Annualized compliance costs for the various elements of the rule are shown in Table 16 below. The table reveals that Engineering and Administrative costs make up the largest portion of the total cost at 66.5 percent. The second largest portion of cost is for Awareness Education at 9.0 percent of total cost.

Table 16: Costs by Rule Element

Ergonomic Rule Cost Module	All businesses		
	Total cost	% of total	Cost per emp.
Rule Review	\$4,283,356	5.3%	\$2.01
Caution Zone Job ID	\$597,232	0.7%	\$0.17
Caution Zone Job Analysis	\$3,618,338	4.5%	\$1.64
Eng/Admin. Control	\$53,467,151	66.5%	\$25.11
PPE	\$661,482	0.8%	\$0.31
Awareness Education	\$7,234,198	9.0%	\$3.40
Haz. Job Training	\$1,450,476	1.8%	\$0.68
Training the Trainer	\$3,555,684	4.4%	\$1.67
Mang. Cost	\$5,578,575	6.9%	\$2.62
Total Estimated Cost	\$80,446,490	100%	\$37.77

11. Overall Impact of the Ergonomic Rule

The department has analyzed the impact the compliance costs of the ergonomic rule on businesses and consumers within the State of Washington. Two bounding assumptions were used to assess the range of impacts of the rule compliance costs will have on businesses and consumers:

1. Complete pass through of compliance costs to consumers. This would occur with a perfectly inelastic demand curve for goods and services. In this case the potential price increase as a result of ergonomic rule costs would be equivalent to the percent of sales that these costs represent.
2. No pass through of compliance costs to consumers, which would represent a perfectly elastic demand curve for goods and services. The costs then would fully displace an equivalent amount of business profits.

Gross Business Income (GBI) and profit data were obtained from the Washington State Department of Revenue. Results of these two comparisons are shown in Table 17 below. For the case of complete pass through of the annualized compliance cost (full impact on prices for consumers), the department forecasts an average increase of only 0.023 percent. The one digit SIC category with the greatest potential impact is SIC 0 (Agriculture, Forestry and Fishing) at 0.117 percent of sales. For the case of no pass through, in which businesses are assumed to absorb all of the costs, the potential impact is a 0.40 percent decrease in profits, again with the largest impact felt in SIC 0 with a potential decrease of 2.52% of profits.⁹ In actuality, the distribution of the burden of the ergonomics rule compliance costs (ignoring any savings in workers compensation fund premiums, reductions in sick leave, etc.) will be somewhere in between the two extremes detailed above and in Table 17. That is, businesses will be able to pass through a certain portion of the new costs to consumers, but because demand curves are not completely inelastic there will be a very small reduction in profits. In summary, the department believes that there is no evidence that the rule will have a significant impact on business sales and profits or on the prices customers' encounter for goods and services.

⁹ This value represents the percent reduction of the rate of return, not a reduction in percentage points; e.g., a reduction of 2 percent would reduce a rate of return from 5.0% to 4.9%.

Table 17: Cost Cost as percent of Gross Business Income and Profits

SIC	Industry	All Businesses		
		Total cost	% of sales	% of profits
0	AGRICULTURE AND FORESTRY	\$4,725,588	0.117%	2.52%
1	MINING AND CONSTRUCTION	\$13,746,752	0.058%	1.40%
2	MANUFACTURING: NON-DURABLE	\$3,960,261	0.010%	0.22%
3	MANUFACTURING: DURABLE	\$11,836,237	0.020%	0.35%
4	TRANSPORTATION & PUBLIC UTIL.	\$8,668,608	0.066%	1.11%
5	WHOLESALE TRADE	\$14,884,649	0.012%	0.42%
6	RETAIL TRADE	\$2,150,878	0.010%	0.10%
7	GENERAL SERVICES	\$5,755,152	0.024%	0.42%
8	PROFESSIONAL SERVICES	\$9,891,003	0.038%	0.49%
9	PUBLIC ADMINISTRATION	\$4,827,362	*	*
SUM		\$80,446,490	0.023%	0.40%

* SIC 9 does not report profits

** This value represents the percent reduction of the profit rate, not an absolute reduction in absolute profit percentage points.
e.g., a reduction of 0.40 percent would change the rate of profit from 5.02% to 5.00%

III. Estimating the Social Benefits of the Ergonomics Rule (RCW 34.05.328(1)(c))

A. Outline of Approach and Methods Used

Benefits were calculated as those accruing to society as a result of the proposed ergonomics rule's adoption. Occupational injuries and illnesses, including WMSDs, impose an enormous burden on workers, families, communities and businesses. Effects of WMSDs extend far beyond short term impacts of pain, suffering, medical treatment and lost days at work to include long term lost earnings, loss of self-esteem, disruption of family life, anger and helplessness. Pain, suffering, loss of esteem and greatly reduced quality of life cannot be readily expressed in numerical terms and are not included in this analysis. However, some dimensions of the burden of WMSDs to society can be easily quantified in monetary terms.

The potential benefits that will be experienced by workers, employers and society at large if these work-related musculoskeletal disorders are reduced in number are simply the other side of the costs they currently impose. Not surprisingly, these benefits are very large, both in terms of reduced pain and suffering and savings in medical, compensation and other costs.

To calculate the benefits of the proposed rule we estimated the following individual elements of the costs which WMSDs impose on society:

- Workers' Compensation Expenditures. These are the expenditures made for such items as medical bills, vocational rehabilitation, and wage replacement for time loss and pensions. In addition to this the resources expended to administer claims must be considered.
- Long-term wage loss. This is the long-term loss of earnings, which extends beyond the time loss period, and is due to the worker's injury-related loss of function, skills or seniority.
- Taxes and fringe benefits. During the worker's period of time loss, that portion of their production, which contributes to their income-based taxes and their fringe benefits, is lost.
- Indirect employer costs. These are the costs borne by the employer for injury-related expenses such as production interruption, accident investigation, recruiting and training replacement workers, and productivity losses.
- Unreported WMSDs. Injuries that go unreported to the workers' compensation system are still a cost to society in terms of lost time and/or medical expenses.
- Effectiveness rate. Based upon the injury-reduction experience of actual ergonomic interventions to address the risk factors covered in this rule, we estimate the decline in WMSDs which can be expected once this standard is fully in effect.
- Unquantified benefits. While not used in our estimate of the total benefits of the proposed rule, it is important to acknowledge that the above costs are not an exhaustive account of all the costs borne by the worker, the worker's family and by society at large. These include household economic losses, ability to perform family and social roles, impact on family relationships, depression, living/working with pain, impacts to disability and welfare systems, and loss of the worker's contribution to community life.

For this analysis we have used data on WMSDs for the years 1995 through 1997. It was our decision not to use data from earlier years because the costs and benefits of the proposed rule will be a function of the *future* level of WMSDs. Since there has been no significant trend in claims rates for the past four years, the best basis for projecting the trend in future WMSDs is the most recent claims experience. Data for 1998 was not used because the full cost of these claims is not yet fully captured in the databases we used to calculate costs of claims. Between January 1, 1995 and December 31, 1997, the annual cost of claims to the Industrial Insurance Fund ("State Fund") was \$278.3 million and \$132.1 million for the self-insured employers in 1998 dollars. Self-insured employers are required to report the occurrence of a compensable claim to the department. However, because complete costs for self-insured compensable claims typically are not reported to

the Department, they had to be imputed using the more complete information from the State Fund. The following process was used to determine the indemnity, and medical costs of WMSDs to self-insured employers.

1. Indemnity payments per claim were conservatively assumed to be 25 percent lower than those for the State Fund due to large self-insured companies' better ability to return injured claimants to work through a greater opportunity to assign them to alternative duties. The number of self-insured compensable claims was multiplied by the average indemnity payment for state fund compensable claims: total cost was then reduced by 25 percent for reasons described above.
2. Medical costs associated with compensable claims were imputed by multiplying the medical costs associated with State Fund compensable claims by the ratio of the number of self-insured to the number of State Fund compensable claims. Medical costs associated with compensable claims was assumed to be the same for State Fund and self-insured claims: no reduction in associated medical costs as with indemnity payments.
3. Self-insured employers do not report their medical claims to the Department in such a way that permit us to determine the type of injury, so the number of such claims for self-insured employers was estimated based on the ratio of compensable-to-medical only claims in the State Fund. This estimated number of self-insured medical only claims was multiplied by the State Fund average cost for medical only claims.

No trend analysis of claims rates was used in the forecast of expected losses since there was no significant trend during this time. Inclusion of prior years' data (1993, 1994) showed a downward trend in incidence rates and in numbers of WMSDs, but the rate of decline has leveled off substantially in the years between 1995-1997.

Total workers' compensation (State Fund and Self-Insured) claims costs for WMSDs averaged \$410.3 million. Table 18 below contains the average indemnity, medical and total claims numbers and payments by one digit SIC for the period from 1995-97. Unspecified claims costs are for those claims that lacked information on the type of business where the injured worker was employed.

Table 18: Annual Workers' Compensation Costs, 1995-97

SIC Category	Total Indemnity Cost	Total Medical Cost	Total cost *	Number Indem. cases	Number Medical cases
unspecified	\$ 11,933,946	\$ 7,324,261	\$ 19,258,208	739	729
SIC 0 Agriculture and Forestry	\$ 4,903,341	\$ 4,429,171	\$ 9,332,512	618	1186
SIC 1 Mining and Construction	\$ 43,639,994	\$ 22,592,315	\$ 66,232,310	2542	3824
SIC 2 Manufacturing-Non durables	\$ 17,624,990	\$ 15,185,786	\$ 32,810,776	1927	3702
SIC 3 Manufacturing-Durables	\$ 20,678,075	\$ 20,103,093	\$ 40,781,168	2287	4801
SIC 4 Transportation & Public Utilities	\$ 19,909,521	\$ 15,892,886	\$ 35,802,407	2195	3207
SIC 5 Wholesale & Retail Trade	\$ 38,817,783	\$ 39,545,004	\$ 78,362,787	5189	10988
SIC 6 Finance, Insurance & Real Estate	\$ 4,566,001	\$ 4,690,051	\$ 9,256,052	475	1041
SIC 7 General Services	\$ 17,315,483	\$ 16,315,145	\$ 33,630,628	2046	3862
SIC 8 Professional Services	\$ 29,823,433	\$ 31,564,980	\$ 61,388,413	4047	8263
SIC 9 Public Administration	\$ 11,993,938	\$ 11,477,969	\$ 23,471,908	1399	3077
SUM SIC1	\$ 221,206,506	\$ 189,120,662	\$ 410,327,168	23465	44681

* Self-Insured claims cost were imputed from State Fund values

B. Direct Social Cost of WMSDs

Cost Savings from Averting WMSDs: Value of Lost Output

In estimating the social benefit to be derived from averting a WMSD injury, the approach used by the Department is to begin by estimating the value of output lost due to workers suffering time loss injuries. To this we add the resources expended to provide medical care to injured workers through the workers' compensation system whether they lost time from work or not, as well as costs incurred to administer these claims. In addition, we estimate the cost of WMSD injuries that go unreported to the workers' compensation system and, finally, we estimate the resources expended by employers when workers suffer from WMSDs (referred to as indirect employer costs).

It should be noted here that by choosing this approach the Department is also choosing not to adopt another approach which is well understood by economists: valuing the avoided injuries according to the willingness-to-pay principle. The merits of the latter approach are mainly that it provides a way to combine both the quantitative and qualitative losses suffered by workers when they are injured. This approach is discussed in greater detail below in the Qualitative Benefits section. The approach adopted by the Department is a conservative one. It does not attempt to place a value on the pain and suffering experienced by injured workers, nor does it include a measure of the costs imposed on members of the workers' households. Therefore, our approach monetizes only a portion of the social benefits that will accrue as a result of the reductions in WMSD injuries expected from the ergonomics standard.

The Department estimates the value of lost output due to time loss injury by estimating the value of lost worker earnings. This is the conventional approach used by most economists, and it relies on the assumption that the value of workers' output is at least as great as the value that the market places on the workers' time while working. This value is expressed by the workers' total pre-tax wages plus the value of any fringe benefits they receive.

Workers' Compensation Costs of WMSD Claims, 1995-1997

Accordingly, the Department began to estimate the value of lost output by calculating the annual average value of all indemnity payments made by the Department and by self-insured employers for time-loss WMSD claims filed during the period 1995-1997. During this period there was an annual average of 23,465 WMSD claims involving time loss reimbursement, and 44,681 claims with only medical cost reimbursement.¹⁰ The average total cost per claim was \$6,021, including both medical reimbursement costs and wage replacement.

The wage replacement payments made for compensable claims take two main forms: temporary total disability payments, which continue while the worker is absent from work until his or her condition stabilizes; and permanent partial disability payments, which compensate the worker for long-term impairment of work function due to the covered injury. Indemnity payments accounted for about 54% of all incurred costs paid for time-loss WMSD claims filed from 1995 through 1997. Medical reimbursement benefits accounted for the rest of these costs. The annual average total incurred costs for claimed WMSD injuries was \$410.3 million in 1998 dollars. The portion of this amount going to indemnity payments for these claims came to \$221.2 million annually.

¹⁰ It should be noted that, due to limitations on information reported to the Department, the number of medical-only claims for Self-Insured employers had to be estimated based on the ratio of medical-to-compensable claims in the State Fund.

Long-Term Lost Earnings

The next step was to add the difference between these wage replacement benefits and the workers' after-tax income. One approach would be simply to follow the wage replacement formulas actually used by the Department when paying indemnity benefits for time-loss claims. However, this approach implies that once the benefit period ends and the worker returns to the job that no further shortfall persists between the worker's earnings and what he or she would have achieved in the absence of the injury. But several recent studies, using data on earnings from state employment security departments for injured workers and matched control groups, show that a substantial fraction of workers who have time-loss injuries experience income losses that continue long after their wage benefits end (Boden & Galizzi, 1999; Reville, 1999; Biddle, 1998). In fact, for workers with longer periods of temporary disability claims or with permanent partial disability awards, the loss of earnings can continue for more than 10 years beyond the date of injury (Boden & Galizzi, 1999). The authors point out that even these estimates are conservative, given the fact that the average age of workers at time of injury is 37, indicating that losses could continue to affect earnings for 25 to 30 years after injury. The Boden and Galizzi study controlled for non-injury-related sources of earnings variation, including age, gender, job tenure, pre-injury earnings levels and stability, industry and occupation. Boden and Galizzi argue that their estimation of long-term lost earnings is conservative for several reasons. As mentioned, they project losses for only 10 years past the observation period (up to 13.5 years post-injury), when losses in some cases continue throughout the worker's lifetime. Secondly, their estimates exclude the value of lost fringe benefits. Finally, they assumed that there were no lost earnings for the large number of workers with medical-only claims, even though such workers may lose up to three days of work due to their injury.¹¹ The burden of this loss may be transferred to the employer by the worker using paid sick leave benefits, but from society's point of view there is still a loss of output.

The long-term earnings losses experienced by injured workers may be due to incomplete recovery of physical function prior to return to work, or they may be due to labor market effects of the worker's injury-related absence which may persist long after the worker recovers. These effects include loss of pre-injury job, loss of seniority or of investment in job-specific skills. They may also be due to stigma attaching to the worker with long periods of injury-related absence. Such workers may come to be viewed as being "injury prone" or "unreliable" causing the worker to have more difficulty finding employment. The authors also find that the longer the duration of time loss the more frequent the episodes of unemployment after the initial return to work (Galizzi and Boden, 1996).

¹¹ The State Fund pays indemnity benefits only for claims where the worker loses more than three days of work. But if the time loss is less than 14 days, the worker is usually not paid wage replacement benefits for the first three days lost. If the employer provides paid sick leave, then the worker is spared this burden. But again, society loses the value of the worker's output for this period.

While the research on long-term lost earnings has not as yet estimated these losses by type of injury, several recent studies strongly suggest that the long-term earnings losses experienced by workers with compensable WMSD injuries will be at least as large as that for all conditions in general. A study based on workers' compensation claims for WMSDs in Washington State from 1990 through 1998 reports several ways in which it appears that WMSD injuries are among the most costly in terms of long-term loss of earnings potential (Silverstein, Viikari-Juntura & Kalat, 2000). First, this study reports that the percentage of non-traumatic WMSD claims involving time-loss is 36.6%, as compared to 23.5% for all claims in general. In addition, the median days lost per claim for WMSDs is 23 days, as compared to 20 days for all claims. That WMSD claims are just as likely to result in time loss of great duration for a fraction of these claims is revealed by the fact that average days lost per WMSD claim is 146 days, while that for all claims is 124 days. WMSDs are more costly than the average both in monetary terms and in the disruption they can cause in the worker's employment pattern. Another study based on Washington State workers' compensation data calculated estimates of "years of productivity loss" by workers with compensable claims filed in 1986 based upon actual accumulated time loss as of mid-1993 and future lost productivity predicted from permanent partial disability ratings (Fulton-Kehoe et.al., 2000). This study found back and neck sprains and lower and upper extremity sprain injuries to be the leading causes of disability in the State. Total years of productivity loss for back and neck sprains were more than five times higher than any other single injury type.

The issue of reduced worker productivity due to chronic musculoskeletal pain while the worker is back on the job is addressed by a study which combines direct measures of worker productivity while on the job and measures of absenteeism and disability. This study found that workers with musculoskeletal injuries lost approximately 21% of their potential productivity due to a combination of absenteeism, disability leave and lower efficiency while working (Burton et.al.,1999).¹²

A pair of studies based upon the same cohort of low back pain claimants in California found that administrative measures commonly used to measure injury duration, such as days to first return to work and time on total temporary disability, substantially underestimate the duration of work disability following the low back injury (Krause et.al.,1999; Dasinger et.al.,1999). Dasinger found that the number of lost workdays as measured by the self-reported experience of claimants far exceeded the duration of wage replacement benefit payments. Workers' compensation administrative data underestimated self-reported total cumulative lost workdays per claim by more than 50% over the 1-3.5 year period following injury.

¹² Since this study looked at a relatively young workforce working in telephone customer service positions at a large company, it is possible that the lost productivity estimates may underestimate the actual experience of workers with WMSD injuries in a representative sample of occupations and industries.

Pransky et. al. (2000) surveyed workers with WMSD claims in New Hampshire one year after injury and found that over half reported continuing effects of the injury on their work performance and daily activities. The study also reported that almost 40% of workers suffered a reinjury after their initial return to work and 44% reported suffering significant financial problems related to their injuries, which were more serious the longer the period of time-loss. One year after injury over 17% reported being unemployed. This last point reinforces the earlier findings by Katz et.al. (1998) who studied the impact on long-term work patterns of carpal tunnel syndrome injuries. Six months following carpal tunnel release surgery 23% of patients reported they were unemployed due to their CTS condition. This number fell to 14% at 18 months and 12% at the 30-month follow-up interviews. Carpal tunnel syndrome also contributed to a significant amount of job instability even among those employed, with over 31% reporting at least one job change over the 30 month period of the study. The major reasons given by patients for not working or for their job change was pain while at work and lack of alternative duties at their former workplace.

In sum, these studies convince the Department that workers with time-loss WMSD claims suffer long term earnings losses at least as great as those found for the average time-loss claim as measured by Boden and Galizzi's research.

Comparing these projected earnings losses to the indemnity payments and permanent partial disability awards received by injured workers, Boden and Galizzi derived an after-tax TTD replacement rate for Wisconsin of 0.55. For PPD claims they calculated an after-tax replacement rate of 0.76. Reville (1999) found after-tax replacement rates for PPD claims in California to be around 0.43. Finally, in Washington State, a recent study using a similar methodology projecting losses for up to 14 years found after-tax replacement rates to be 0.40 for TTD claims and 0.43 for PPD claims (Biddle, 1998). Biddle used a discount rate of 2.3% to express future lost earnings into present values. This is the rate commonly used by researchers in this field and recommended by the Social Security Administration. The argument is made that for investments which generate benefits over many years a lower discount rate should be used for amenities, such as improved health, than that used for costs. As living standards rise over time, it is argued, the value society places on health relative to other goods also rises. One way to place greater weight on these future preferences is to reduce the rate at which future benefits are discounted. In our analysis, however, we have adopted the more conservative 5% rate for both costs and benefits, which reduces the contribution of benefits accruing in more distant years to the total. Adjusting Biddle's replacement rates for this factor brings them to 0.43 for TTD claims and 0.46 for PPD claims. Weighting these rates by the distribution of TTD and PPD claims for MSD we estimate that workers' compensation indemnity benefits replace about 44.8% of the workers' long-term lost earnings after tax. Applying this to the \$221.2 million in annual indemnity payments for claims filed in 1995-97, we estimate annual total lost income of \$493.8 million in 1998 dollars due to workers' suffering claimed WMSD injuries in this period.

Because the value of lost output is equal to the value of total worker compensation including that portion of earnings which must be paid in taxes, the next step is to convert the after-tax earnings loss to a pre-tax basis. This replaces that portion of compensation that goes toward Federal income tax, Social Security tax and Medicare tax. Note that Washington State has no state income tax, and that since sales taxes are paid out of after-tax income they are not included in this calculation. Because injured workers will earn somewhat less than they would have without the injury, the relevant adjustment to Federal income tax payments should take into account their *marginal*, rather than average, tax rate. Adjustments must also be made for the number of dependents and marital status of injured workers. Boden and Galizzi (1999) estimate an overall tax rate of 28.1% for Wisconsin (1999), while OSHA applies a rate of 30% for the nation as a whole. Because Washington State has no state income tax, we adopt a tax rate of 25% in our calculations. Applying this to the value of lost income above, we estimate total pre-tax earnings losses due to claimed WMSD injuries of \$658.4 million in 1998 dollars.¹³

The next step is to add the value of lost fringe benefits to the already computed lost pre-tax income. Fringe benefits include sick leave, vacation leave, health and dental insurance, retirement plans and child care allowances, among many others. This package of benefits varies widely across industries and across firm sizes. The Bureau of Labor Statistics conducts surveys of employers and reports estimates of the cost to employers of providing fringe benefits. The 1999 BLS survey estimates that about 27% of total compensation goes toward providing fringe benefits for workers. This would imply we should multiply the pre-tax earnings loss by a factor of 1.37 to arrive at the value of lost total compensation and, therefore, lost output. But the Department recognizes that this average estimate for the level of fringe benefits provided varies greatly across industries. The BLS reports its estimates by broad industrial categories, but does not provide any estimate for agriculture. In Table 3 we include the BLS estimates of the cost of fringe benefits as a proportion of total compensation by industry. For agriculture we assumed that the cost of providing fringe benefits would be only half as high as the lowest industry fraction. Applying these values to the level of lost earnings reported above, the Department arrives at an annual estimate of \$903.4 million in 1998 dollars for the value of lost output due to claimed WMSD injuries.

Finally, we add to this the cost of the resources expended by the State and by self-insured employers to administer these claims. We estimate that costs of claims administration average 14% of the total incurred cost of a claim for the State Fund, whether the claim is for time loss or only for medical costs. For self-insured employers, we follow the estimate of the National Academy of Social Insurance (NASI), which is that such employers spend 11% of total incurred costs administering these claims (NASI, 1997). Applying this figure to the total incurred cost for time loss claims, we estimate \$29.8

¹³ It should be noted that many workers with compensable claims do not receive compensation for the first three days of lost work. We have not attempted to estimate the amount of this loss, so our calculations of the value of lost output are biased downward by an unknown but probably small amount.

million for administering the claims, for a total estimate of \$933.2 million in annual total costs for covered time-loss WMSD claims.

To summarize: the indemnity cost of WMSDs was converted to full productivity loss by adding the following components: long-term wage loss, lost tax payments, lost fringe benefits and insurance fund administrative costs. Table 19 below summarizes, at the one digit SIC level, the steps taken to calculate the full productivity loss from indemnity WMSD payments.

Table 19: Full Productivity Losses Associated with WMSD Indemnity Payments

SIC Category	Full Wage Replacement - After Tax	Full Wage Replacement - Before Tax	Full Wage + Fringe benefits	Comp. Fund Admin. Costs	Total Productivity Loss
Unspecified	\$ 26,638,189	\$ 35,517,585	\$ 48,214,457	\$ 1,614,620	\$ 49,829,077
SIC 0 Agriculture and Forestry	\$ 10,944,923	\$ 14,593,231	\$ 16,747,556	\$ 684,052	\$ 17,431,608
SIC 1 Mining and Construction	\$ 97,410,393	\$ 129,880,523	\$ 182,352,255	\$ 6,091,686	\$ 188,443,941
SIC 2 Manufacturing-Non durables	\$ 39,341,370	\$ 52,455,160	\$ 74,591,238	\$ 2,338,485	\$ 76,929,722
SIC 3 Manufacturing-Durables	\$ 46,156,271	\$ 61,541,694	\$ 90,650,916	\$ 2,677,379	\$ 93,328,295
SIC 4 Transportation & Public Utilities	\$ 44,440,753	\$ 59,254,338	\$ 85,622,518	\$ 2,609,398	\$ 88,231,916
SIC 5 Wholesale & Retail Trade	\$ 86,646,563	\$ 115,528,750	\$ 149,638,614	\$ 5,252,847	\$ 154,891,460
SIC 6 Finance, Insurance & Real Estate	\$ 10,191,935	\$ 13,589,247	\$ 19,160,838	\$ 614,657	\$ 19,775,496
SIC 7 General Services	\$ 38,650,509	\$ 51,534,012	\$ 68,282,566	\$ 2,402,431	\$ 70,684,997
SIC 8 Professional Services	\$ 66,569,952	\$ 88,759,936	\$ 117,606,915	\$ 3,925,329	\$ 121,532,244
SIC 9 Public Administration	\$ 26,772,099	\$ 35,696,132	\$ 50,545,723	\$ 1,544,004	\$ 52,089,727
SUM SIC1	\$493,762,957	\$ 658,350,609	\$ 903,413,596	\$29,754,888	\$ 933,168,484

Medical Costs Associated with WMSDs

The Department and self-insured employers spent a combined annual average of \$189.1 million on medical cost reimbursement for WMSD compensable medical and medical-only claims during the period 1995-97.¹⁴ In the case of medical-only claims it should be recognized that some workers suffer adverse consequences from these injuries which extend beyond the medical costs incurred to treat these injuries, in spite of the fact that they did not lose more than three days from work. Nevertheless, in our calculations we have not included any estimate of these losses, whether they take the form of losing three or fewer days from work, or whether they take the form of lower productivity and/or greater absenteeism from work in the post-injury period. Applying the State Fund and self-insured cost factors for claims administration to the total for medical reimbursement, we estimate total costs at \$214.5 million per year in 1998 dollars. The combined total annual cost to Washington in 1998 dollars from *all* covered WMSD claims is approximately \$1.147 billion dollars.

C. Unreported WMSD Injuries

Driven by rising workers' compensation costs in the late 1980s and early 1990s, many studies focussed on the extent to which benefits are paid to workers who in fact were not entitled to receive them. But while these studies found that the amount of worker-generated fraud was miniscule as a fraction of total losses, only recently has an equivalent amount of research effort been put into the converse question: In what percentage of cases are workers entitled to receive workers' compensation benefits but do not apply for them? Earlier studies of WMSD prevalence often noted the degree of underreporting of injuries on company OSHA 200 logs or in company medical records. Punnett found in a study in several auto manufacturing plants that only about 20% of workers with WMSD symptoms had reported to the company's medical department (Punnett, 1999). Pransky et.al. (1999a) found that although 30% of workers in one survey reported either lost time or work restrictions due to their work-related pain, only 5% had officially reported the condition in the previous year. A pair of recent studies in Michigan directly tested the assertion that a significant percentage of workers eligible to receive workers' compensation benefits do not file for claims (Rosenman et. al., 2000; Biddle et. al., 1998). In the 1998 study, this team of researchers showed that between 12% and 63% of all workers in Michigan who had been judged by a medical professional to have a work-related repetitive strain injury filed a workers' compensation claim (Biddle et. al.,

¹⁴ The Department does not receive sufficient data on self-insured medical-only claims to allow us to calculate the number of WMSD medical-only claims they incur. Instead, the Department imputed the number of these claims by assuming that the ratio of medical-only claims to total claims was the same for self-insured employers as it was for the State Fund. The cost of these claims was also assumed to be the same as it was for the State Fund.

1998). Limitations in the dataset prevented the researchers from narrowing this broad range. But the follow-up study by Rosenman et. al., which involved interviews with some 1,600 workers whose WMSDs had been reported by health practitioners, as required under Michigan law, showed that only 25% had filed a claim for workers' compensation benefits. The reasons given by workers for not filing included: belief that the injury was not serious enough to cause them to miss work, that even if they missed work they would be covered by sick leave, and that their medical expenses would be covered by other insurance (Rosenman et. al., 2000). Other reasons often given include fear of reprisal, a belief that pain is a normal consequence of work, and a lack of management response to prior reports (Pransky et.al., 1999a). So the burden of these costs is shifted either onto the workers' health insurance system, the workers' sick leave account or onto the workers' own savings. Since this study was conducted in another state, in which incentives to file for benefits in the workers' compensation system might differ from those in Washington State, we believed it to be prudent to assume that the rate at which workers filed for workers' compensation benefits in Washington State was twice that of the rate found in this study, or 50%. We also assumed that the average cost of these unreported injuries was substantially below the average of that for reported injuries: \$1,500 per unreported WMSD injury in lost wages, fringe benefits and medical expenditures. We assume, conservatively, that there are no long-term earnings losses associated with this category of injury. The impact of this is to add \$102.2 million to the total annual burden of WMSD injuries in the State, bringing the total annual monetized cost of WMSD injuries to \$1.250 billion dollars.

D. Indirect Employer Cost of WMSD injuries.

Workers compensation fund and associated fund administrative costs are the direct costs that employers bear for WMSD injuries. Research has shown that there are sizable injury related costs that are not covered by insurance, which nonetheless are borne by the employer. These costs are commonly referred to as uninsured or indirect costs. Indirect costs include productivity losses due to an injured workers absence and reduction in co-workers' productivity following the injured workers' return to work. Also included in the indirect cost category are the additional recruitment and training efforts for replacement workers and additional company administrative costs for dealing with the injury episode. Legal expenditures required to defend an employer from litigation by injured workers also falls in the category of indirect costs. A company with a high level of WMSD injuries may have to resort to over employment in-order to keep the business viable. A number of researchers have attempted to estimate the magnitude of indirect costs to employers. Estimates of the size of indirect costs range from 10 to 2000 percent of direct costs. This wide range is due to both the large variances of indirect costs across industry groups, and the inclusiveness of the researcher's investigation of indirect costs. The indirect cost studies evaluated for this analysis are summarized in Table 20 below.

Table 20: Summary of Studies on Indirect Costs of Injuries

<u>Authors</u>	<u>Terms</u>	<u>Results</u>
Heinrich (1931,1959) U.S.	<p>Direct costs; Victim's indemnity costs, medication and hospitalization</p> <p>Indirect costs:</p> <p>A: Time remunerated (paid back) but no work by the accident victim the day of the accident</p> <p>B: Time remunerated (paid back) but no work by the other employees which are stopped because of the accident</p> <p>C: Time lost by the supervisor and other managers</p> <p>D: Time lost for the security, medicine, or infirmary</p> <p>E: Damages to machines, tools, materials</p> <p>F: Production interruption, delayed delivery, Lost goods / sales</p> <p>G: Social benefits paid without production</p> <p>H: Loss of profits caused by productivity loss from lost employee</p> <p>I: Wage paid to accident victim with reduced production</p> <p>J: Reduced employee moral and heightened fear of accidents.</p> <p>K: Electricity, heat, rent</p>	<p>4:1 indirect to direct costs</p> <p>Note: insurance admin. cost included in the indirect costs category.</p>
Simonds and Grimaldi (1956, 1984) U.S.	<p>Insurance costs; Assessment of the insurance system, includes admin. costs, plausible funds and prevention costs of the insurance system for the non-insured ;</p> <p>Heinrich definitions: less recruiting of replacements, productivity loss of other workers, machine stoppage, Expenses: heating, electricity, and rent</p>	<p>Lost time case \$465 (1982\$)</p> <p>Medical intervention case \$115</p> <p>First aid case \$25</p> <p>No lost time case \$850</p> <p>1:1 uninsured to insured cost</p>
Bird (1974) U.S. *	Insured and Non insured	\$1 to \$3 various expenses (Hiring, training, replacement, inquiry [interview/ evaluation], wages and \$5 to \$50 material damages for each dollar of insured costs
Levitt, Parker, Samuelson (1981) U.S. Construction sector	Direct costs; Re: Heinrich definitions and they add admin. costs without more precise indirect costs; Re: Simonds and Grimaldi definitions- they add the cost of productivity loss of other workers	<p><u>Lost time direct costs</u> <u>Ratio Direct:indirect</u></p> <p>0 - \$3000 1:4.1</p> <p>\$3000- \$4999 1:1.6</p> <p>\$5000- \$9999 1:1.2</p> <p>+ \$10,000 1:1.1</p> <p><u>No lost time</u> <u>Ratio Direct:Indirect</u></p> <p>0 - \$200 4.2</p> <p>\$200- \$399 5.1</p> <p>+ \$400 9.2</p>
Andreoni (1986)	Review of methodologies for estimating the financial costs of occupational injuries.	<p><u>Direct:Indirect</u></p> <p>Lower limit 1:1.58</p> <p>Median 1:4.10</p>

		Upper Limit 1:20
Leopold and Leonard (1987) U.K. Construction sector	Direct costs; Additional accident payments; Added premiums, material damages, indirect legal costs; only wage costs	Indirect to direct costs 1 to 4.5 Note: some direct costs would be considered indirect (i.e. variable portion of ins. premium) by other authors.
Laufer (1987) Israel Construction sector	Non verifiable costs; fixed insurance costs not variant in terms of verifiable accident costs	Conventional method (Insured / non-insured costs); costs of non-insured represents 1.59 % of profits before taxes; The method of verifiable/ non verifiable costs increases the incentive for prevention (the author does not cite figures) Estimated Uninsured to insured ratio 0.2:1.0
Klen (1989) Finland	Direct costs; Compensation paid to the victim, transport to the hospital, Difference between wage and compensation, social benefits, wage paid the day of the accident Indirect costs: Investigation, admin. costs, lost time from the other workers, productivity loss, material damages, interest in the insurance premiums	Indirect to Direct costs 1 to 5; 60% of accident costs are absorbed by the employer, 30% by public admin and 10% by the worker
Rinefort (1977)	Survey of 140 Texas chemical, paper and wood product firms. Followed the analysis recommendations of Simonds.	Found that firms w/ low WC costs spent more on safety than firms w/ high WC costs. Uninsured to insured ratio approx. 1:1
Hinze and Applegate (1991)	Survey of 103 construction industry injuries.	Indirect to direct ratios Med. only 1:1 (1.6:1.0 w/ claims) LWD 0.35:1 (4.4:1.0 w/claims)
Brody, Le'tourneau and Poirier (1990)	Review article and report on own 13-industry analysis.	Indirect costs Quebec Ind. \$1,100 (Canadian) Canadian road trans. \$2,900 Indirect to direct ratio approx. 1:1
Oxenburgh (1991)	Estimation of indirect costs for occupational injuries at a Swedish automotive industry	<u>Direct:Indirect</u> 1:2.1
Oxenburgh (1993)	Results from a survey of manufacturing and manual handling jobs in Australia. Direct and indirect costs reported by employers	<u>Direct:Indirect</u> 1:0.75

Heinrich was probably the first investigator to systematically evaluate indirect and direct costs of workplace injuries. He evaluated a very large number of industrial accidents from the 1920s through the 1940s and determined an indirect to direct cost ratio of 4:1. Adjusting for Heinrichs' inclusion of insurance administrative costs in the indirect cost category and the lower wage replacement rate for injured workers 60 years ago, we can roughly estimate current indirect cost of 200 percent for this data set. The more recent literature that we reviewed provides strong support for indirect costs being at least 100 percent of direct costs (Oxenburgh 1991 and 1993, Andreoni, 1986 and Brody, 1990). As a conservative assumption the Department has decided upon indirect costs of 75 percent of direct workers' compensation incurred costs. Accordingly we estimate annual indirect

employer costs of \$308 million in 1998 dollars. This brings the estimate of total monetizable costs of all WMSD injuries in Washington State in 1998 dollars to \$1.558 billion per year.

The costs for medical, unreported WMSDs and indirect employer losses are summarized in Table 21 below.

Table 21: Medical, Unreported WMSD, Indirect Employer and Total Social Cost for WMSDs

SIC Category	Medical + Administrative Costs	Unreported WMSDs Costs	Indirect Employer Costs	Total Social Costs of WMSDs
Unspecified	\$ 8,315,207	\$ 2,202,157	\$ 14,443,656	\$ 74,790,097
SIC 0 Agriculture and Forestry	\$ 5,047,072	\$ 2,705,825	\$ 6,999,384	\$ 32,183,889
SIC 1 Mining and Construction	\$ 25,745,966	\$ 9,549,098	\$ 49,674,232	\$ 273,413,237
SIC 2 Manufacturing-Non durables	\$ 17,200,637	\$ 8,444,114	\$ 24,608,082	\$ 127,182,556
SIC 3 Manufacturing-Durables	\$ 22,706,024	\$ 10,633,060	\$ 30,585,876	\$ 157,253,254
SIC 4 Transportation & Public Utilities	\$ 17,975,853	\$ 8,103,314	\$ 26,851,805	\$ 141,162,887
SIC 5 Wholesale & Retail Trade	\$ 44,896,259	\$ 24,265,744	\$ 58,772,090	\$ 282,825,553
SIC 6 Finance, Insurance & Real Estate	\$ 5,321,407	\$ 2,274,232	\$ 6,942,039	\$ 34,313,175
SIC 7 General Services	\$ 18,578,785	\$ 8,861,692	\$ 25,222,971	\$ 123,348,445
SIC 8 Professional Services	\$ 35,719,530	\$ 18,465,497	\$ 46,041,310	\$ 221,758,581
SIC 9 Public Administration	\$ 12,955,552	\$ 6,714,438	\$ 17,603,931	\$ 89,363,648
SUM SIC1	\$ 214,589,063	\$ 102,219,173	\$ 307,745,376	\$ 1,557,722,096

E. Anticipated Effectiveness of the Ergonomics Rule

The social benefits from the ergonomics rule will be derived from the decrease in WMSDs that follow the reduction, or elimination of WMSD hazards in the workplace. The benefits are dependent and proportional to the degree to which workplace WMSD hazards are reduced by the ergonomics rule. In this analysis the fraction or percentage

decrease in WMSDs is referred to as rule effectiveness, and was assessed using two different approaches. The first approach was to evaluate the literature on ergonomic interventions (programs) in the workplace. The second approach involved the epidemiological literature on the risk associated with exposure to the workplace WMSD hazards.

In the first approach a literature search focusing on publications and reports on the effectiveness of ergonomic interventions at workplaces was carried out. A total of 63 reports and publications on the success of ergonomic programs in a wide range of work environments were evaluated and determined to be of sufficient quality for determining rule effectiveness. Publications and reports that were anecdotal in nature, or lacked detailed information were not included in this evaluation. Typically, rule effectiveness was presented as a reduction in WMSD claims, lost-work days or a reduction in WMSD claims costs. Table 22 below summarizes the average, and median effectiveness of the ergonomic interventions as well as the confidence intervals around the averages.

Table 22: Rule Effectiveness Measures

Effectiveness Measure	Number of studies	Average Reduction	Median	Confidence Interval *
Number of WMSD injuries	37	49.5%	50%	7.3%
Lost work days	24	65.0%	65%	10.4%
Days per injury	3	56.6%	65%	20%
WMSD costs	22	64.8%	64%	9.8%
Cost per claim	5	43.6%	56%	35%

* Computed 95% confidence interval

The observed average reduction in number of WMSD injuries was 50 percent, while the average reduction in WMSD costs was 64 percent. Our literature search also revealed that there was a decrease in the severity of WMSD injuries that were reported after implementation of ergonomic programs as seen in the reduction in days per injury and cost per claim in Table 22 above. The reduction in injury severity is also reflected in the observation that the reduction in cost of WMSD claims is greater than the reduction in WMSD injuries: 65 versus 50 percent. The 1997 GAO report on Private Sector Ergonomic Programs (GAO, 1997) also supports the observation that these programs reduce the severity and cost of the remaining WMSD injuries. For a more complete presentation of the ergonomic intervention studies evaluated see Appendix F.

The second approach involved a review of the epidemiological literature on the risk of injury from exposure to ergonomic risk factors. Epidemiological studies of WMSD hazards typically report the relative risk (RR), or odds-ratios (OR), for selected outcomes

(claims, specific injuries or impairments) for workers exposed to different levels of hazard. These scientific studies relate exposure to increased probability of injury or impairment in a statistical manner. The epidemiological studies reveal both the extent to which WMSDs are caused by workplace ergonomic risk factors and the degree to which WMSDs can be reduced by controlling exposure to these risk factors. To use the epidemiological data we focused on studies that approximated the caution and hazard job exposure levels to the six ergonomic risk factors described in the rule. The percent reduction in probability of injury was estimated for situations when exposure was reduced from hazard job to caution job (H-C) or low exposure job (H-L) levels for the six ergonomic risk factors. Table 23 summarizes these findings.

Table 23: Percent Reduction in Injuries with Reduction in Exposure to Ergonomic Risk Factors

Risk Factor	Industry	Reference	OR or RR Differential *	Exposure Differential
Awkward Postures				
Hands above head > 2 hours / day	Auto assembly Case-referent	Punnett 2000	55% 80% 56%	C-L H-L H-C
	Meat packing and chemical workers Cross-sectional	Frost 1999, 1998	81%	H-L
	Construction workers Cross-sectional	Holmstrom 1992	27% 45% 25%	C-L H-L H-C
	580 orthopedic patients, 996 clinical controls	English 1995	70% 55% 80% 60%	C-N C-L H-L H-C
Work with back bent >30° without support	Auto assembly Case-referent	Punnett 1991	76% 84% 30%	L-N C/H-N C/H-L
Work with back bent >45° without support > 2 hours/day	Auto assembly Case-referent	Punnett 1991	50%	H-C
	Carpet layers and carpenters	Jensen et al. 1997, Jensen et al. 2000 (in press)	81% 60% 53%	H-L C-L H-C
	Auto workers case-referent	Kerr 2000	30%	C-N
High Hand Force				
Holding 2 pound object with pinch or pinch force > 4 pounds >2 hours	Industrial workers Case-control	Roquelaure, 1997	70-80%	C-N
	580 orthopedic patients, 996 clinical controls	English 1995	75%	C-N
	Industrial workers	Silverstein 1986,1987	80%	H-L

	Cross-sectional			
Forceful pinching (>2 lbs) with high repetition > 3 hours/day	Auto assembly workers and general population Cross-sectional	Fransson-Hall, 1995	78% 74% 87%	H-N?
	Meatpacking workers	Kurppa 1991	80% 95% 92% 91% 86% 84%	H-N or L H-N or L H-N or L H-N or L H-N or L H-N or L
Forceful gripping (> 10 lbs) with high repetition > 3 hours/day	industrial workers in 6 industries	Silverstein, 1986, 1987	97% 93%	H-L
	Fish processing	Chiang et al. 1993	38% 44%	H-L
Forceful grip (>10 lbs) & wrist flexion>45° or extension >30° > 3 hours	(CTS patients & general population) Case control	DeKrom, 1990	33% 66% 89% 65% 29% 57% 82% 57%	L-N C-N H-N H-C L-N C-N H-N H-C
Highly Repetitive Motion				
Same motion every few seconds > 6 hours		Silverstein 1987	82%	H-L
	Industrial workers Cross-sectional	Latko, 1999	68%	H-L or C
	Industrial workers Cross-sectional	Leclerc et al, 1998	47%	H-L
Repetitive wrist flexion>45° or extension/ulnar deviation >30° > 3 hours	Population based case control	Nordstrom 1997	50%	H-C
	US population	Blanc, 1996	40-50% 70-80% 50%	C-L H-L H-C
Repetitive wrist flexion>45° or extension/ulnar deviation >30° > & forceful exertions > 2 hours		Baron et al, 1992	88%	H-L
Intensive keying > 7 hours/day	Clerical workers Cross-sectional	Rossignol, 1987	44% 75% 78% 13%	L-N C-N H-N H-C
	Newspaper workers	Bernard, 1994	23%	C-L

			52% 38%	H-L H-C
	Office workers prospective	Nelson et al, 1998	44%	H-C?
Keying > 4 hours with awkward postures	322 Office workers Cross-sectional	Bergqvist et al 1995	78%	H-L?
Intensive keying > 4 hours per day	Newspaper workers	Bernard, 1994	15% 55% 38%	C-L H-L H-C
Intensive keying > 4 hours per day	VDT operators using > 4 hours/week	Faucett & Rempel, 1994, 1996	55% 75% 25%	C-L H-L H-C
Repeated Impacts				
Using knee as hammer > 1/minute > 2 hours/day	Carpet layers; tile & terrazo setters, millwrights, bricklayers	Thun et al, 1987	69% 81%	H-L
Manual Handling combination of load, lift frequency, posture, twisting	N=284 in 50 jobs from 4 industrial sites Cross-sectional	Waters, 1999 assigned highest LI for rotating jobs, overestimates exposure & underestimates risk	56%	H-C
	403 industrial jobs with repetitive lifting	Marras 1995	41%	H-C
Knee as a hammer	Carpet layers; tile & terrazo setters, millwrights, bricklayers	Thun et al, 1987	69%	H-C
Heavy, Frequent, Awkward Lifting				
Lift > 75 pounds 1/day	Registered Nurses Cross-sectional	Mandel and Lohman , 1987	29%	H-C
	Nurses	Arad & Ryan, 1986	60%	H-C
	Nurses longitudinal	Stobbe et al, 1988	55%	H-C
	Nurses longitudinal	Venning et al, 1987	55%	C-L
Lift > 55 # > 10/day	Nurses Cross-sectional	Smedley et al, 1995	29%	C-L
Lift >10 # >2/minute >2 hours	Auto assembly	Punnett, 1991	55%	C-L
Lift >25# above shoulder, below knee, extended reach > 25/day	Multiple	Kelsey, 1984	68%	C-L
	Working population Ontario	Liira et al, 1996	33% 57%	H-C H-C
	Construction workers, prospective	Latza, 2000	62% 31% 44%	H-L H-C C-L

Moderate to High Vibration				
Moderate/High vibration > 2 hours/day	65 chain saw operators & 31 controls	Bovenzi et al, 1991	76% 74% 65% 66%	H-L or C H-L or C H-L or C H-L or C
	222 forestry workers and 195 controls, cross- sectional	Bovenzi et al, 1995	56%	H-C

* Odds Ratio and Relative Risk

The average reduction in WMSD injury rate across all risk factors was found to be 50 percent when the hazard exposure was reduced from the hazard to the caution zone level (the minimum hazard reduction required by the rule). Reducing the exposure from the hazard level to a low level of exposure across all risk factors resulted in a reduction in the injury rate of nearly 60 percent.

Estimated Rule Effectiveness

Based on the ergonomic intervention and epidemiology information summarized above the Department conservatively estimates that the ergonomics rule will prevent 40 percent of WMSD injuries and 50 percent of WMSD costs once all programs are fully effective. These are average numbers; actual injury and cost reductions will vary by industry. These numbers are somewhat conservative as both the intervention and epidemiological information summarized in Tables 22 and 23 indicate that larger injury and cost reductions can be expected.

Upper and Lower Confidence Intervals

Confidence intervals for mean effectiveness rate (central estimate) of 50 percent were established based on the variance of the effectiveness parameter reported in the intervention studies evaluated. A lower confidence limit (LCL) and an upper confidence limit (UCL) for the effectiveness rate were established by adapting the confidence intervals presented in Table 22: the confidence intervals were scaled to the 50 percent effectiveness rate. The LCL was estimated at 42.4 percent effectiveness and the UCL at 57.6 percent effectiveness. The central, LCL and UCL rule effectiveness values were used to establish the central, lower and upper estimates of the ergonomics rule: in effect the 95 percent confidence interval for benefits (WMSD cost savings) from the ergonomics rule.

Time to Full-Effectiveness

There will be a lag between the implementation of an ergonomic program at a particular business or in a particular industrial sector and the achievement of the full reductions in the numbers of WMSD injuries and costs. The literature review of ergonomic interventions in the workplace revealed that ergonomic programs generally achieved full effectiveness within one to two years of hazard reduction: see the 1997 GAO report for some examples. The Department assumes somewhat conservatively that ergonomic programs will achieve full effectiveness within two years of being fully implemented (exposure to WMSD hazards reduced to prescribed levels).

E. Total Savings due to Ergonomics Rule

The total annual savings (social benefit) due to the ergonomics rule can be determined by multiplying the total annual social cost of WMSDs in Washington State, presented in section D above, by the projected rule effectiveness numbers presented in the previous section: 50 percent. The department estimates that the annual savings, or social benefit, from the ergonomics rule once it is fully effective will be \$778.8 million. Because the benefits from the ergonomic rule are delayed due to the six year phase-in and the assumption of a two year lag until full effectiveness is achieved, the benefits must be converted to an annualized present value form (compliance costs for the rule were treated in a similar fashion). Table 24 summarizes the lower, central and upper estimates for the annualized present value of savings from the ergonomics rule.

Table 24: Lower, central and Upper Estimates of Ergonomic Rule Benefits

SIC Category	Central estimate of benefits	Present Value of Benefits-incorporates rule phase-in timeline and 2 yr. delay until full effectiveness		
		Lower bound estimate	Central estimate	Upper bound estimate
unspecified	\$37,395,049	\$11,107,763	\$15,773,323	\$15,089,791
SIC 0 Agriculture and Forestry	\$16,091,945	\$6,139,560	\$7,333,904	\$8,200,796
SIC 1 Mining and Construction	\$136,706,619	\$49,408,061	\$58,400,017	\$66,918,205
SIC 2 Manufacturing-Non durables	\$63,591,278	\$23,461,287	\$27,835,167	\$31,620,982
SIC 3 Manufacturing-Durables	\$78,626,627	\$26,289,855	\$31,301,391	\$35,269,048
SIC 4 Transportation & Public Utilities	\$70,581,444	\$26,081,898	\$30,951,774	\$35,141,953
SIC 5 Wholesale & Retail Trade	\$141,412,777	\$53,150,766	\$63,295,330	\$71,285,381
SIC 6 Finance, Insurance & Real Estate	\$17,156,587	\$6,718,287	\$8,062,185	\$8,918,771
SIC 7 General Services	\$61,674,223	\$23,115,935	\$27,518,178	\$31,017,430
SIC 8 Professional Services	\$110,879,291	\$42,189,194	\$50,349,756	\$56,422,765
SIC 9 Public Administration	\$44,681,824	\$16,707,525	\$19,870,201	\$22,446,989
SUM SIC1	\$778,797,662	\$284,370,129	\$340,691,227	\$382,332,110

F. Qualitative Benefits of the Ergonomic rule

A large amount of costs borne by workers could not be quantified in the cost-benefit analysis. For people who experience work-related musculoskeletal disorders (WMSDs), the consequences can be disastrous. Normal everyday tasks become difficult or impossible, and pain interferes with normal family life. Family members must often assume additional responsibilities and replace lost income through acquisition of a second job or sale of personal property such as a home or car (Morse, et al. 1998).

Although these are real social losses, they could not be quantified and they are therefore excluded from the benefit to cost ratio. They include:

- Household economic losses
- Diminished ability to perform family and social roles
- Impact on family relationships
- Depression

- Living/working with pain
- Other financial losses
- Impacts to disability and welfare systems
- Lost community benefits.

The connections of these losses to the WMSD and the interrelationships between these losses are illustrated with quotes from injured workers who testified at the Washington State hearings on the ergonomics rule. Several injured workers testified that pain of WMSDs reduced their ability to care for themselves and others. Many workers were unable to sleep and perform normal and productive life activities. Due to pain of those disorders, they curtailed contributions to work, family and community life. It is clear to the Department that the qualitative economic and societal losses associated with WMSDs are large and important, and although they are not included in the cost-benefit calculation, they should be *valued* as social benefits of the ergonomics rule.

Household economic losses

Economists recognize that household production, although unremunerated, creates immense value and meets important needs. Household work, including cooking, cleaning, washing, yard work, household improvements and repairs creates value. Disability interferes with the ability to create value through home production. Rather than spending time in productive household activities, injured workers often spend their time in self maintenance and in lengthy court battles in order to secure payment for medical bills and reinstatement of benefits.

Consider how injured workers' WMSDs affected their ability to care for themselves and others in their homes.

"I found myself sleeping with ice packs on my arm and my shoulder so that I wouldn't be awakened with the pain... this went on for months, and it affected every area of my life. I couldn't push a vacuum cleaner; I couldn't pull weeds in the garden; I couldn't brush my teeth with a regular toothbrush; I had to buy an electric toothbrush and hold it with two arms. Thank heavens for technology. I couldn't hold a knife strong enough, long enough, hard enough to chop an onion; and it hurt to put a sweater on over my head... I had to take my vacation comp time off to be sick, to make up for the difference for what L&I paid because I was off...My kids had a hard time, too. I looked normal, so they didn't understand why I couldn't go to the grocery store alone. I couldn't push the grocery cart. This is not a trivial problem. I was selling my employer the right to my labor, but it turns out I was selling my upper body strength. I was selling the right to go bowling, to garden, to cook and clean for

my family, and so much more. My employer got all that from me. That's way more than they are paying for.”

“To perform normal tasks like cutting vegetables, pulling weeds, driving, doing laundry, putting gas in my car or scrubbing my kitchen floor caused me extreme pain... Recommendations from the occupational therapist were not acted upon, and in 1994 I was fired from my job as I would not return to work against the recommendations of my physician. Lengthy, costly painful legal battles secured two carpal tunnel surgeries. Another lengthy legal battle settled my constructive discharge. Six years later I am improved, but I will always have tendinitis and hand pain.

“When I became an employee at the converting plant, my main purpose was to stuff product into a big box as fast as I could for eight hours a day. Within a short period of time, I noticed that my hands began to swell, and I couldn't sleep very well at night in a prone position in a bed as most of us do. I started sleeping sitting up a lot so that I could have circulation in my hands... As time went by, it got worse, and finally, it got to the point I couldn't simply -- I couldn't button my shirt. I couldn't do anything. My fingers were swollen to the size of a sausage. I couldn't clench my hands in a fist. I couldn't even flex my fingers. Frankly, I couldn't pick up a fork to feed myself. I had to stop work because of tendinitis.”

Household economic losses due to work-related MSDs could be estimated at the price of labor for the time lost in performing those activities (Levenstein, 1999). Although the Department recognizes the important role of household production to the economic and social fabric, none of these considerations were included in this benefit to cost ratio.

Ability to perform family and social roles

Injured workers often find themselves unable to perform tasks that, prior to development of a WMSD, enabled them to perform as functional members of family and society.

Injured workers testified that family members often suffer from the inability of the injured to care for family. Family members were denied health insurance and other benefits if workers were unable to return to work.

“I'm ... a sole wage earner and head of household. In March of '98, I received a repetitive injury with the resulting loss of wages, which, of course, affected me and my family. I eventually then had surgery on my shoulder and rotator cuff and collarbone; the resulting medications that I had to go through; my surgeon being told

that he cannot be my advocate as changes weren't made in my workplace; he could only deal with me medically. A month after my surgery I was informed that I had a loss of benefits. My family would no longer receive any benefits.”

For some workers the perceived threat of future reinjury is itself disabling and appears to discourage a return to normal social roles (Tarasuk and Eakin 1994). Planning becomes difficult and uncertainty about what activities might cause additional pain add to the disruption of family life. Punnett (1999) found that nearly one-fourth of workers with MSDs had to change or give up leisure or household activities because of their upper extremity problems. Changes to lifestyle, relationships, hobbies and sports, future plans, sleep, self-image and emotional state were negatively affected by repetitive strain injuries. This affects identity and family role, and that in turn affects family relationships. (Ewan et al, 1991).

Family relationships

Injuries and illnesses are very disruptive to family life. There is evidence that workers who sustain WMSDs have elevated levels of stress and higher incidence of divorce than workers who do not (Morse et al., 1998; Feuerstein et al 1985).

Children are often expected to take on additional household responsibilities and to care for injured parents, and that may detract from normal social development. (Reid et al, 1991).

Injured workers testified that as a result of pain caused by their WMSDs, they were not able to interact with their children in normal ways, or to participate in other family members' development.

“Right now, when I go home, I have a third grader that's trying to learn cursive writing, and I can't even write a letter of upper case Ds without being in intense pain. I'm not going to have that opportunity to teach my third grader how to write cursive Ds again. I mean, it's like -- you don't get to put your life on a rerun or an instant replay. You don't get second chances.”

“I wasn't able to even raise my arm. I'd raised three young kids - they're actually still young - and I've never been able to lift them up off the ground; they've always been handed to me. So that's the impact on my life.”

Depression

Many injured workers become depressed when they become unable to perform productive and socially constructive roles in society. Because workers with soft tissue disorders may look normal, it is often hard for others to understand their suffering. The overall mental health status of individuals suffering work injuries has been found to be worse than in the general population and it is particularly poor for those who have been out of work for at least one year following an injury (Pransky et al, 1999b). Self reported feelings of anxiety and depression are higher among individuals with work-related repetitive strain injuries (Helliwell et al, 1992). Injured workers in Pennsylvania report sleep disturbances, sexual problems, depression, lowered self-esteem and, occasionally, suicidal tendencies (Dawson, 1994)

Living and Working with Pain

Living and working with pain is a tremendous personal cost and continual frustration for injured workers. Pain often forces workers to curtail outside activities or to use sick leave and vacation time in an attempt to manage pain.

“And, you know, I’m going to be in pain the rest of my life. It’s that simple. I’ve got to take pain pills every day. And I was never used to that. And I’ve had to readjust my whole life, you know. And, you know, it is important.”

“As a single parent I could not afford to reduce my working hours; so I worked in pain; I took anti- inflammatories; and I curtailed my outside activities, to the degree that it took away my freedom. It took away my freedom to make choices about what to do with my body on my time. ...with the inability to use my hands for even the simplest task, such as getting ready for work and driving to work. These are the days when I simply cannot come into work or need to work less than my eight hours and, thus, have been granted the FMLA, which is the Family Medical Leave Act, to use for time loss at work.”

“If I have spasms in my back, if I have pain in my leg, I cannot work. It takes away from my sick time, and because my hospital has a policy that says that you can only have six sick occurrences a year, believe me, I try to minimize it.”

Other Financial Losses

Even if an injured worker returns to work, the risk of reducing hours or of dropping out of the labor market altogether increases (Burkhauser and Daly, 1996). Studies find that

employer accommodations improve stability of employment once employees return to work (Butler, Johnson and Baldwin 1995; Burkauer, Butler and Kim 1995). However, Gunderson and Hyatt (1996) found evidence that employers shift the burden of accommodations by lowering wages. A study by Haveman and Wolfe (1990) examine changes in real equivalent family income and find that the ratio of disabled to non-disabled real earnings for households is 0.72; in other words, families do not “make up” the difference in lost earnings. Morse et al (1998) found that out of pocket expenses were \$489 on average per worker. Workers with WMSDs were more likely to have moved for financial reasons, including having lost a home. They were also more likely to have lost a car due to financial reasons and less likely to have been promoted than people who did not sustain WMSDs (Morse et al 1998). Lost personal property was not included in the cost-benefit ratio.

Impact on Disability and Welfare Support Systems

A recent study of injured workers in British Columbia shows that workers’ compensation claimants are more likely to receive welfare benefits than are injured workers who did not file claims. Thirty-three percent of claimants also had welfare benefits while 10% of injured workers who did not file claims had welfare benefits (Hertzman et al 1999). This suggests that both groups of injured workers (those who file claims and those who do not) rely on more than one means of income support. Thus, it is expected that reduction in WMSDs is expected to also reduce welfare enrollment in the State of Washington and in national disability programs. It will also reduce payments from private long term disability systems (those funded by employers, workers and unions.) However, the potential impact in reducing cross subsidization of income and medical replacement for disabled workers was not included in the quantitative analysis of the benefits and costs associated with the ergonomics rule.

Community effects

When workers are injured, communities suffer. Workers are often uncompensated for full wages and benefits lost. Loss of disposable income, or the portion of income that is used for consumption of goods and services, has an impact on local and State economies. The loss of disposable income and sales tax revenues has multiplier effects in the local and State economies that were not considered in the cost-benefit ratio.

Prior to their injuries, many workers with WMSDs were productive and contributing members to their local communities. The value of healthy workers’ volunteering and participating in committees at work, churches, unions, schools, homeless shelters and other contributions to society could not be enumerated as financial benefits to the ergonomics rule.

One injured worker testified to her life before and after her injury:

“My customer service skills and sales quotas were excellent. I was a United Way solicitor. I was a union steward. I was involved with the YWCA school for the homeless. I was a member of numerous union and company committees... I was the recipient of numerous awards and customer commendations. In other words, I was good, but in 1991 I began having problems sleeping. I would be awakened because the sensation of feeling in my hands and arms was gone. My hands and arms were numb. My neck was on fire, and when the feeling finally returned to my hands, they were in constant pain. Upon a visit to my physician, he felt that the problems were due to the repetitive nature of my work. I was then diagnosed with tendinitis and cervical strain... My neck will always hurt, and I have degenerative spondylosis in my neck. My life is changed irrevocably forever.”

Many workers face retraining very late in their work lives. Many workers who had to leave their jobs also gave up income and retirement benefits. The pain and financial loss will make it difficult for them to enjoy their retirement years, and this could also be considered a loss to families and local communities.

“I’m a heavy equipment operator.. I’ve been such for 35 years. I’ve had shots in my wrist because my hands go to sleep at night. And when I drive, they go to sleep. Now my knees and hip joints have all got arthritis from the vibration and the pounding. The doctor tells me to be retrained. I’m 55 years old. I don’t want to work for \$7 an hour. That’s all I have to say.”

“When I was losing sensation in my fingers and I hurt through my wrist, and I thought, I might have grandchildren someday, and I will want to hold them, and if I’m going to hold them, I’m going to need to be able to feel them. At that point, I went off work on an L&I disability, and I lost income as a result.”

Summary of Qualitative Benefits

Dollar figures could not be attached to such personal losses such as being able to pay the bills, shop, hug a child, cook, or enjoy life well into one’s retirement. Although some economists have tried to estimate the value of life, costs such as diminished health and quality of life are virtually impossible to estimate in monetary terms. The task is further complicated because WMSDs persist for many years. (Punnett, 1999). While some household losses can be monetized (Levenstein 1999), those were not quantified in this cost-benefit analysis.

Although these qualitative costs of WMSDs could not be quantified and expressed in the benefit to cost ratio, the Department emphasizes that the full costs of WMSDs to injured workers, spouses and children, is much greater than the dollar value expressed in Table 21. Benefits from the reduction of WMSDs and the benefit to the State’s economy as a

whole of having productive and injury-free members of society are at least as important as the monetary benefits that could be quantified

G. Willingness to Pay Valuations

In an alternative approach, some economists have attempted to place a market value on the amount of money individuals would trade for reduction of risks to life and health. The dominant approach to obtaining those estimates are to use labor market data on workers' wages to infer attitudes toward risk (Viscusi, 1993). In a review of the literature on the subject, W. Kip Viscusi finds that most estimates of wage-risk tradeoffs regardless of severity are clustered in the \$25,000-\$50,000 range with a median estimate of \$43,000 per injury. The value of averting lost workday injuries is clustered in the \$50,000 range (Viscusi, 1993).

Problems with willingness-to-pay methodology

The fundamental problem with this approach is that it relies upon individuals' labor market behavior to impute the value of risk reduction. According to economic theory, the risk-compensating "wage premium" paid to workers who face higher job hazards represents the workers' own evaluation of the value of that loss of health and safety. But such transactions as accepting a job or deciding to change jobs are taken for many reasons and it is difficult to determine how much of a role is played by risk aversion. In addition, many workers are poorly informed about the risks they face on the job, particularly when these risks are not of an immediate life-threatening nature. If this is the case then the wage premium will not be an adequate reflection of the workers' true willingness to pay to avoid risk. Moreover, worker perception of the risk of chronic occupational disease which may have a significant latency period, is notoriously imperfect. Furthermore, this approach requires workers to be able to change jobs easily. But for older workers with significant investments in seniority, job-specific skills or pension benefits, such easy mobility is far from a reality. Finally, the wage premium is unlikely to adequately "price" risk because it can only reflect the individual workers' evaluation of the hazard when they are acting as *individual* decision-makers. It can not reflect the value which they would place upon the reduction of risk as a *social* goal.

While the Department did not undertake a value of life estimate for the ergonomics standard, our valuation of the monetized benefits per injury avoided is approximately \$29,000. This is well below what economists have found when using the willingness-to-pay approach for valuation of injury risks. Therefore, we are comfortable that our analysis falls well within the range of estimated benefits from injury reduction.

IV. CONCLUSION

A. Monetized Costs and Benefits of the Ergonomic Rule

Ergonomic compliance costs were determined in section II for the following rule elements:

1. initial rule review
2. job identification
3. job analysis
4. educational awareness
5. hazard job
6. training of the evaluator
7. engineering and administrative controls
8. personal protective equipment
9. managerial and administrative time

The present value of the total annualized compliance cost for the entire state of Washington was estimated at \$80.4 million. This translates into an annual cost of \$37.77 per employee and \$529 per business establishment.

The savings or benefits from the ergonomics rule were estimated in section III and include savings from reductions in the following WMSD elements

1. workers compensation expenditures-indemnity and medical
2. lost taxes and fringe benefits
3. long-term wage loses
4. administrative expenditures
5. unreported WMSDs
6. indirect employer expenditures
7. “qualitative” social costs of WMSDs

The present value of the total annualized social benefits for the entire state of Washington was estimated to be \$340.7 million. This is equivalent to an annual benefit of \$160 for each worker in the state.

B. Comparison of the Ergonomic Rule Costs and Benefits

The central annualized cost estimate for compliance with the ergonomic rule, which was derived in section II of this document, was \$80.4 million in 1998 dollars. The central annualized estimate of social benefits for the rule, derived in section III, was \$340.7

million dollars, giving a Benefit Cost Ratio (BCR) of 4.24: a BCR of 1.0 indicates that benefits just equal costs. The high benefit cost ratio reveals that estimated social benefits from the rule significantly outweigh the social costs. Interpreted another way, this ratio means that there is a 424 percent annual return on the investments (rule costs) required to reduce WMSDs.

Often when there is a potential for variance in the estimated parameters used in a cost-benefit analysis, economists will attempt to determine upper and lower bound limits for the benefits and costs. Inclusion of the variance in the cost and benefit predictions requires presentation of the BCRs in a 3 by 3 matrix. One axis of the matrix represents lower, central and upper estimates for cost and the other lower, central and upper estimates for benefits. Nine BCR's are presented in each table describing benefit and cost combinations from low benefit versus high cost ratio to a high benefit versus low cost ratio. Table 25 contains the 3 x 3 Benefit-Cost matrices for the ten one-digit SIC categories and for all SIC categories. The results indicate that even for the combination of high cost and low benefits the BCR is 3.13, which is significantly greater than the break-even point. Looking at the 3 by 3 matrices for the one-digit SIC categories one can see that the BCR is always significantly greater than 1.0 for all of the cells in the 3 by 3 matrices, except for one cell in the SIC 0 matrix. This one cell in the lower left-hand corner of the 3 by 3 matrix with a value of 1.14 represents the low benefit and high cost BCR for SIC 0 (agriculture and forestry). This ratio reveals that benefits still slightly exceed costs, but it should be noted that this is an extreme worst case scenario with a probability of less than one in two hundred. In other words, this scenario has a less than a 0.5 percent chance of occurring, based on the data and information used by the department in this analysis. Note that the central estimate value of 1.55 is significantly greater than the break-even point. Because a significant number of assumptions used in preparing this document were quite conservative the department believes that it is likely that the BCR in the low benefit versus high cost corner of the SIC 0 matrix will exceed 1.0. In addition the department has identified significant qualitative benefits (described in the section III (F)) that could not easily be monetized and included in the benefits portion of this analysis. Considering both quantitative and qualitative benefits the department is of the opinion that the social benefits of the ergonomics rule will significantly outweigh the social costs in each of the one digit SIC categories.

Summary

The department has estimated the annualized present value of compliance costs for the ergonomic rule to be \$80.4 million and the annualized present value of social benefits to be \$340.7 million. Comparing the costs and benefits of the rule demonstrates that the benefits to society greatly exceed the costs of compliance: a benefit-cost ratio of 4.24 to 1.0. The central benefit to cost ratios, calculated and presented above, show that for every one digit SIC category, the benefits to society outweigh the costs of compliance.

Table 25

3 by 3 Benefit Cost Matrices for the Washington State Ergonomics Rule

Statewide Benefit Cost Ratios

BCR	Low Benefit	Central Benefit	Upper Benefit
Low Cost	4.03	4.83	5.42
Central Cost	3.53	4.24	4.75
Upper Cost	3.13	3.75	4.21

SIC 3 MANUFACTURING:DURABLE

BCR	Low Benefit	Central Benefit	Upper Benefit
Low Cost	2.50	2.98	3.36
Central Cost	2.22	2.64	2.98
Upper Cost	2.00	2.38	2.68

SIC 7 GENERAL SERVICES

BCR	Low Benefit	Central Benefit	Upper Benefit
Low Cost	4.52	5.38	6.07
Central Cost	4.02	4.78	5.39
Upper Cost	3.61	4.30	4.85

SIC 0 AGRICULTURE AND FORESTRY

BCR	Low Benefit	Central Benefit	Upper Benefit
Low Cost	1.51	1.80	2.02
Central Cost	1.30	1.55	1.74
Upper Cost	1.14	1.36	1.52

SIC 4 TRANSPORTATION AND PUBLIC UTILITIES

BCR	Low Benefit	Central Benefit	Upper Benefit
Low Cost	3.44	4.09	4.64
Central Cost	3.01	3.57	4.05
Upper Cost	2.67	3.17	3.60

SIC 8 PROFESSIONAL SERVICES

BCR	Low Benefit	Central Benefit	Upper Benefit
Low Cost	4.56	4.56	5.45
Central Cost	4.27	5.09	5.70
Upper Cost	3.99	4.76	5.34

SIC 1 MINING AND CONSTRUCTION

BCR	Low Benefit	Central Benefit	Upper Benefit
Low Cost	4.03	4.76	5.46
Central Cost	3.59	4.25	4.87
Upper Cost	3.24	3.83	4.39

SIC 5 WHOLESALE TRADE AND RETAIL TRADE

BCR	Low Benefit	Central Benefit	Upper Benefit
Low Cost	3.87	4.61	5.20
Central Cost	3.57	4.25	4.79
Upper Cost	3.31	3.94	4.44

SIC 9 PUBLIC ADMINISTRATION

BCR	Low Benefit	Central Benefit	Upper Benefit
Low Cost	6.12	6.12	7.27
Central Cost	3.46	4.12	4.65
Upper Cost	2.28	2.71	3.06

SIC 2 MANUFACTURING: NON-DURABLE

BCR	Low Benefit	Central Benefit	Upper Benefit
Low Cost	6.89	8.17	9.29
Central Cost	5.92	7.03	7.98
Upper Cost	5.20	6.17	7.00

SIC 6 FINANCE, INSURANCE AND REAL ESTATE

BCR	Low Benefit	Central Benefit	Upper Benefit
Low Cost	3.42	4.11	4.54
Central Cost	3.12	3.75	4.15
Upper Cost	2.83	3.40	3.76

These findings signify that the department has fulfilled the requirements of the APA (RCW 34.05.328(1)(c)) and EO97-02 (criteria 6) that the benefits of a rule, or regulation, exceed the costs.